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Shimizu et al.

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(54) **SEWING MACHINE, EMBROIDERY UNIT, AND NON-TRANSITORY COMPUTER-READABLE MEDIUM STORING SEWING MACHINE CONTROL PROGRAM**

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D05C 5/02 (2006.01)

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CPC . ***D05B 19/12*** (2013.01); ***D05C 5/02*** (2013.01)

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CPC D05C 9/04; D05C 9/22; D05C 5/02; D05B 19/02–19/10
USPC 700/136–138; 112/102.5
See application file for complete search history.

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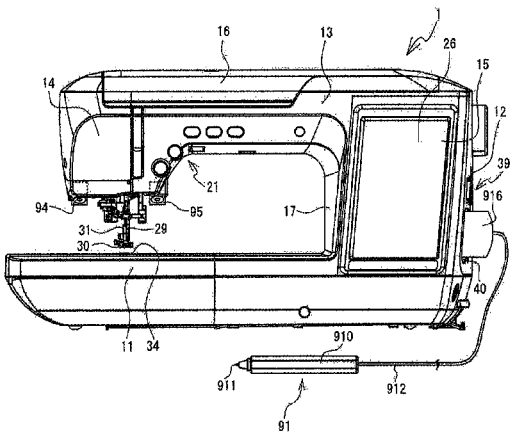
Primary Examiner — Danny Worrell
(74) *Attorney, Agent, or Firm* — Oliff PLC

(57) **ABSTRACT**

A sewing machine includes at least one detecting portion, a processor, and a memory. The at least one detecting portion is configured to detect an ultrasonic wave that has been transmitted from a transmission source. The memory is configured to store computer-readable instructions that instruct the sewing machine to execute steps including identifying a position of the transmission source of the ultrasonic wave based on information pertaining to the ultrasonic wave that has been detected by the at least one detecting portion, and controlling sewing based on the position of the transmission source that has been identified.

14 Claims, 18 Drawing Sheets



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Mar. 4, 2014 Office Action issued in U.S. Appl. No. 13/788,979.
Feb. 26, 2015 Office Action issued in U.S. Appl. No. 13/789,061.
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FIG. 1

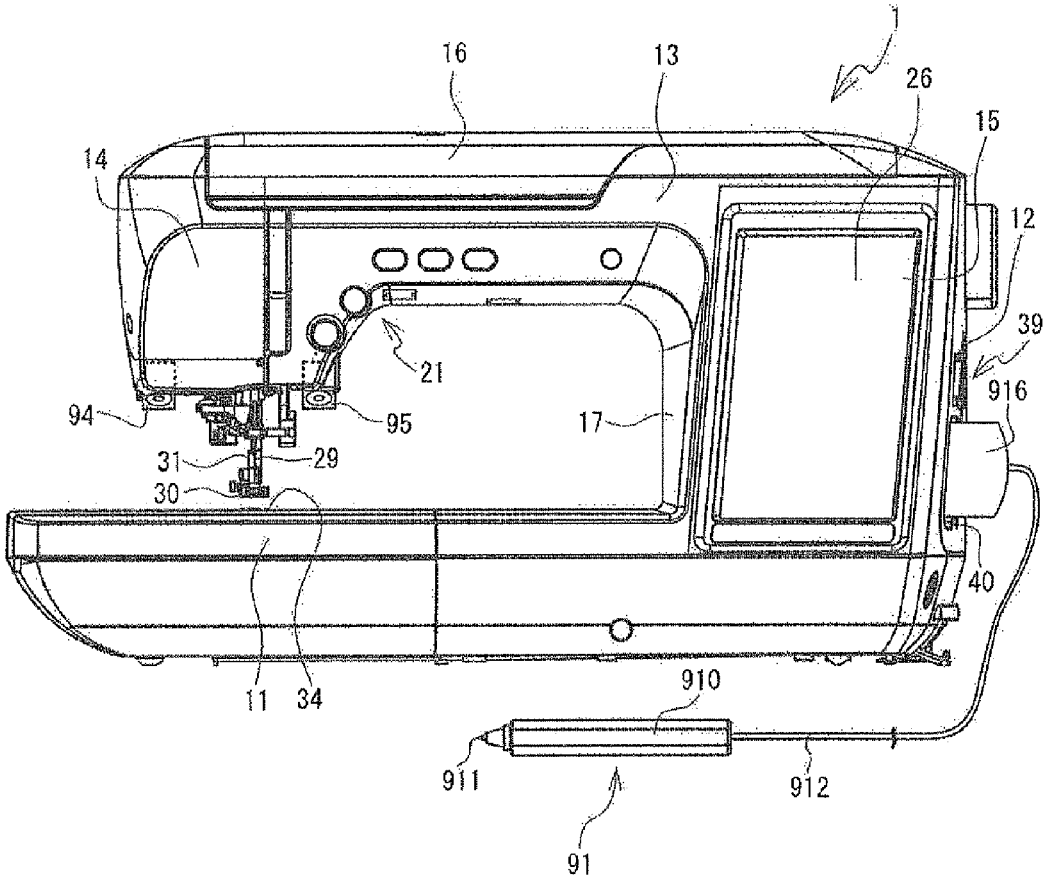


FIG. 2

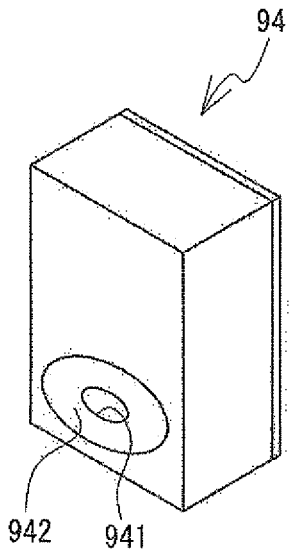


FIG. 3

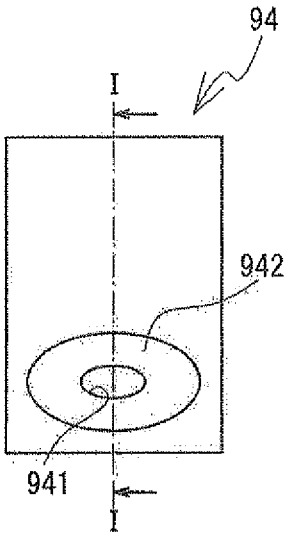


FIG. 4

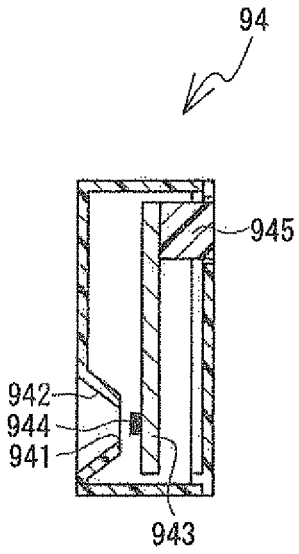


FIG. 5

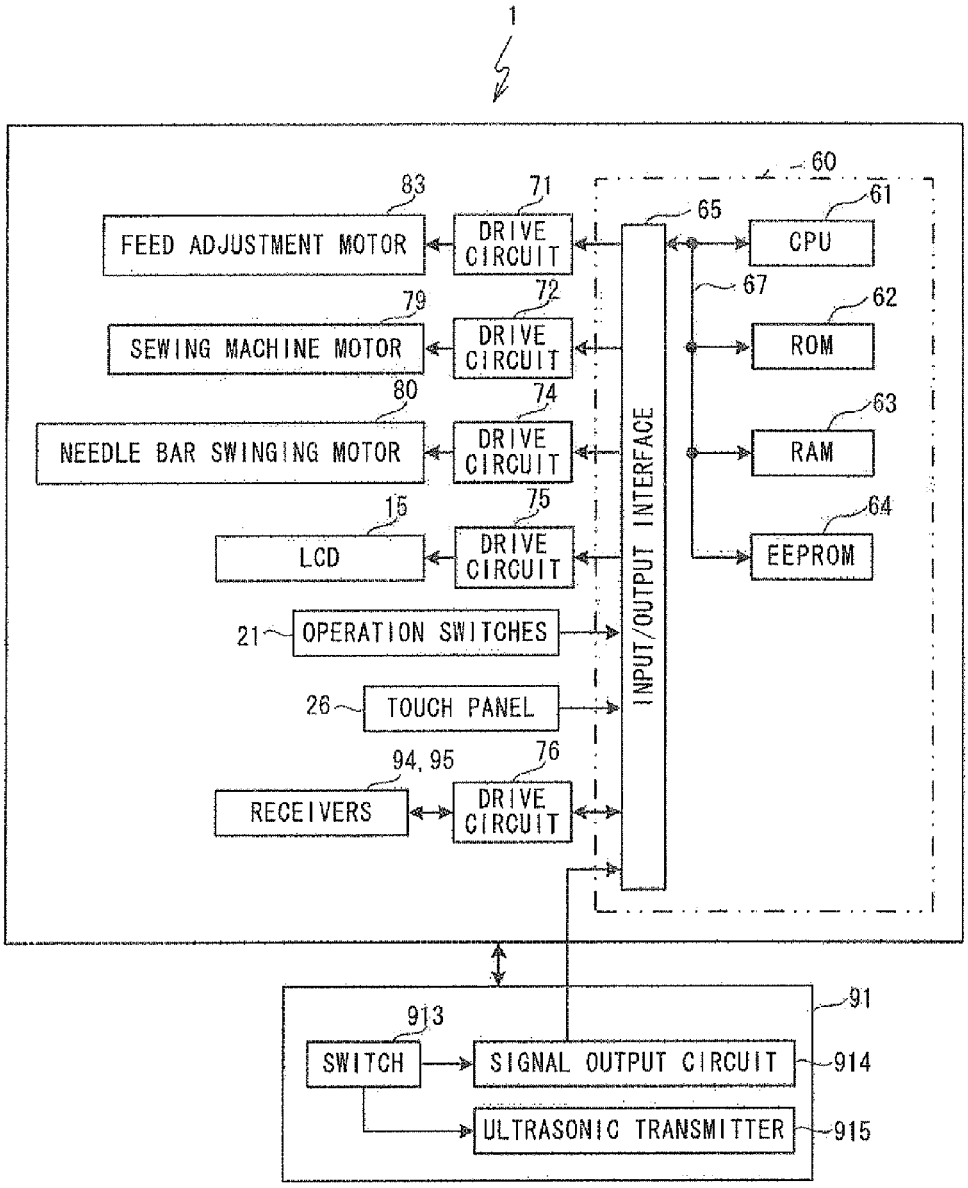

1
60
83
71
65
61
FEED ADJUSTMENT MOTOR
DRIVE CIRCUIT
CPU
67
79
72
62
SEWING MACHINE MOTOR
DRIVE CIRCUIT
ROM
80
74
63
NEEDLE BAR SWINGING MOTOR
DRIVE CIRCUIT
RAM
15
75
64
LCD
DRIVE CIRCUIT
EEPROM
21
OPERATION SWITCHES
INPUT/OUTPUT INTERFACE
26
TOUCH PANEL
94, 95
76
RECEIVERS
DRIVE CIRCUIT
91
913
SWITCH
SIGNAL OUTPUT CIRCUIT
914
ULTRASONIC TRANSMITTER
915

FIG. 6

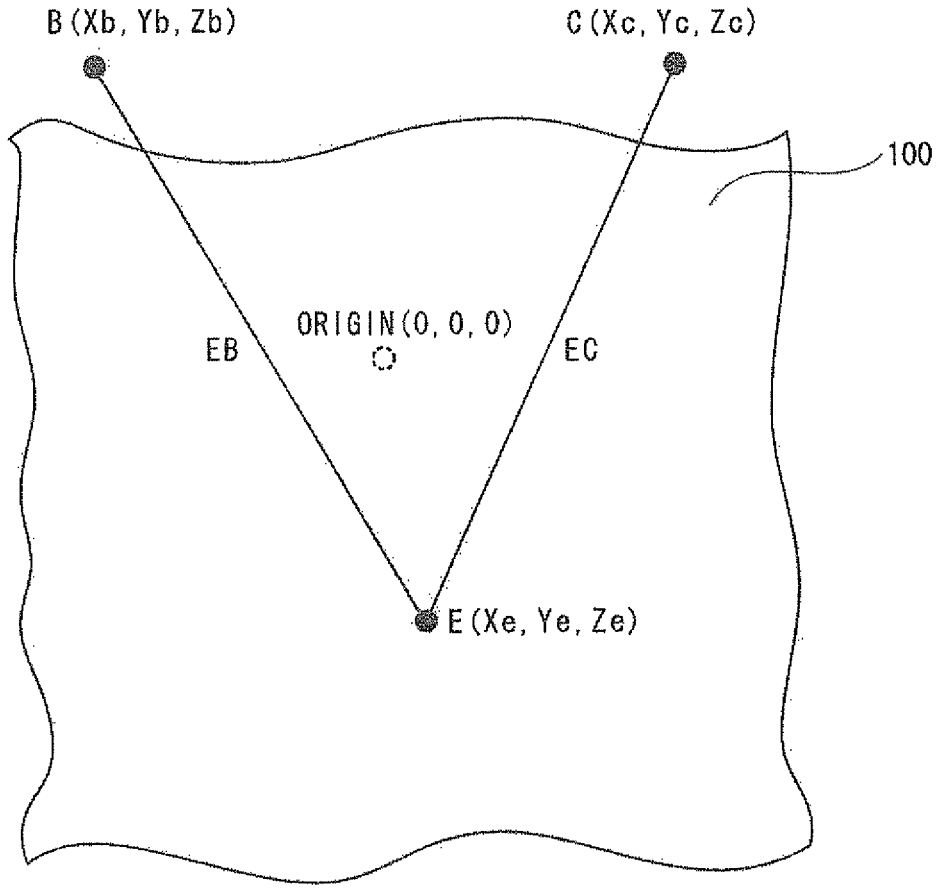


FIG. 7

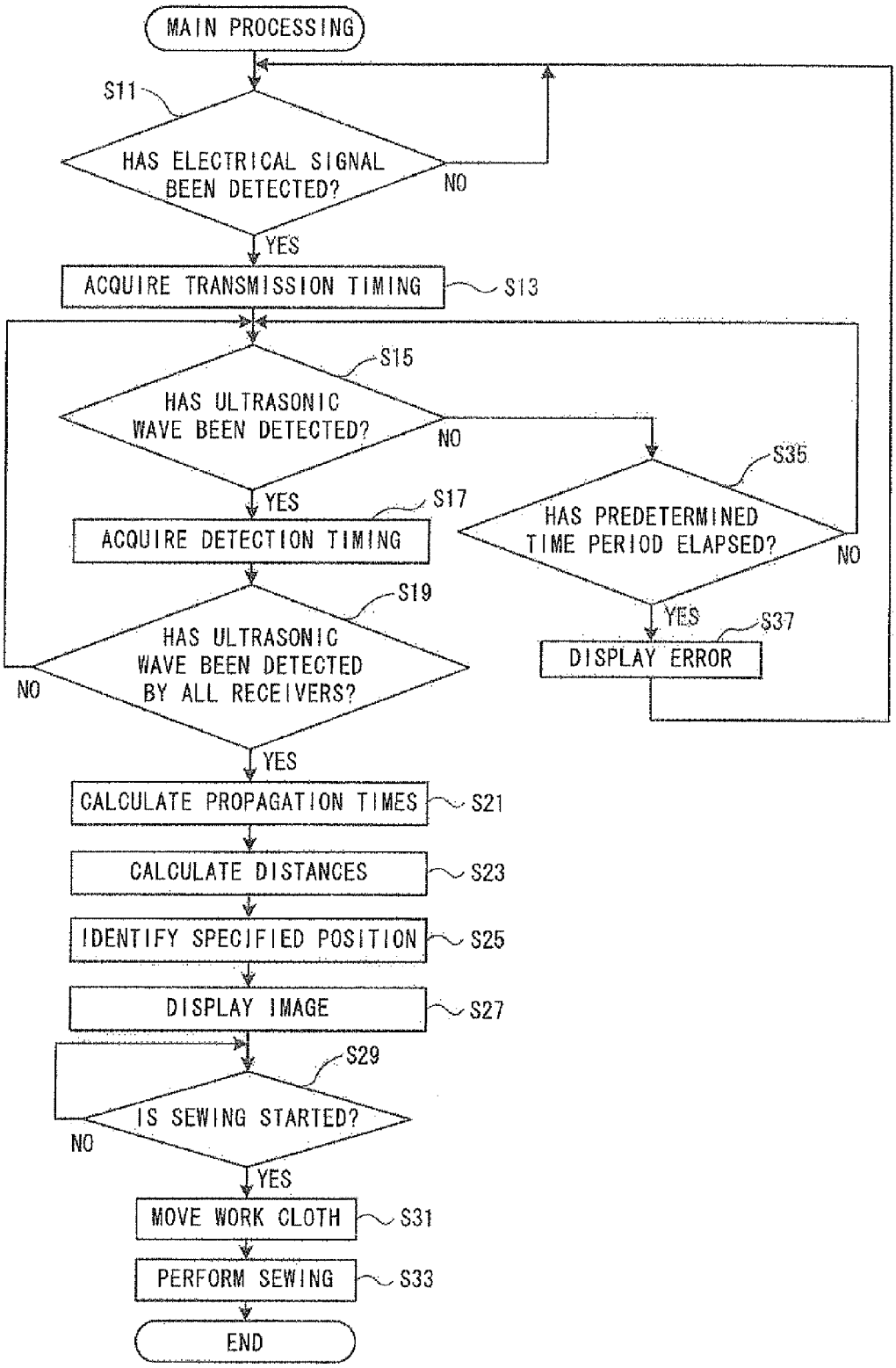
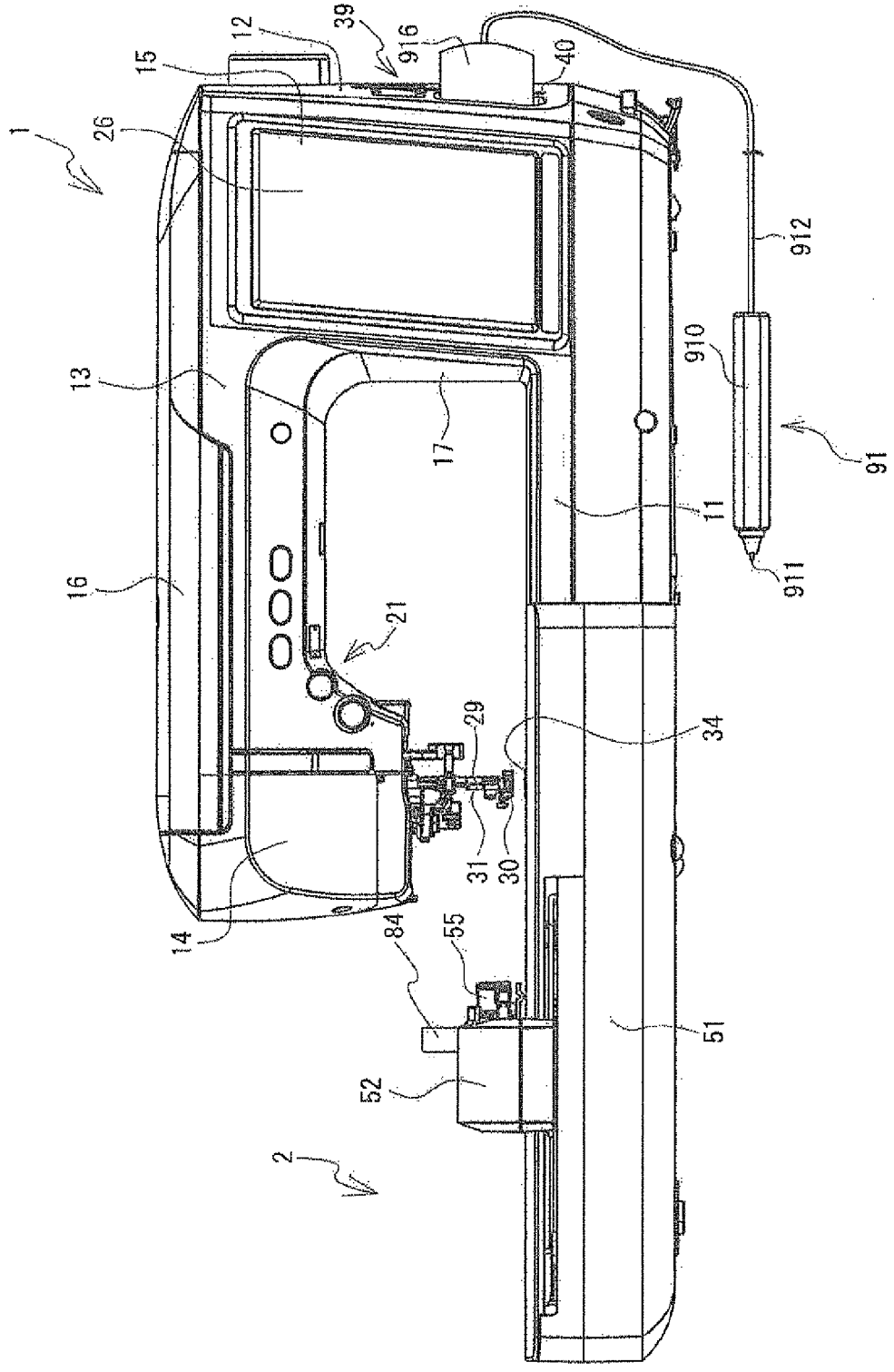

MAIN PROCESSING
S11
HAS ELECTRICAL SIGNAL BEEN DETECTED?
NO
YES
ACQUIRE TRANSMISSION TIMING
S13
S15
HAS ULTRASONIC WAVE BEEN DETECTED?
NO
YES
S17
ACQUIRE DETECTION TIMING
S19
HAS ULTRASONIC WAVE BEEN DETECTED BY ALL RECEIVERS?
NO
YES
S35
HAS PREDETERMINED TIME PERIOD ELAPSED?
NO
YES
S37
DISPLAY ERROR
CALCULATE PROPAGATION TIMES
S21
CALCULATE DISTANCES
S23
IDENTIFY SPECIFIED POSITION
S25
DISPLAY IMAGE
S27
S29
IS SEWING STARTED?
NO
YES
MOVE WORK CLOTH
S31
PERFORM SEWING
S33
END

FIG. 8


1
2
11
12
13
14
15
16
17
21
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34
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84
91
910
911
912
916

FIG. 9

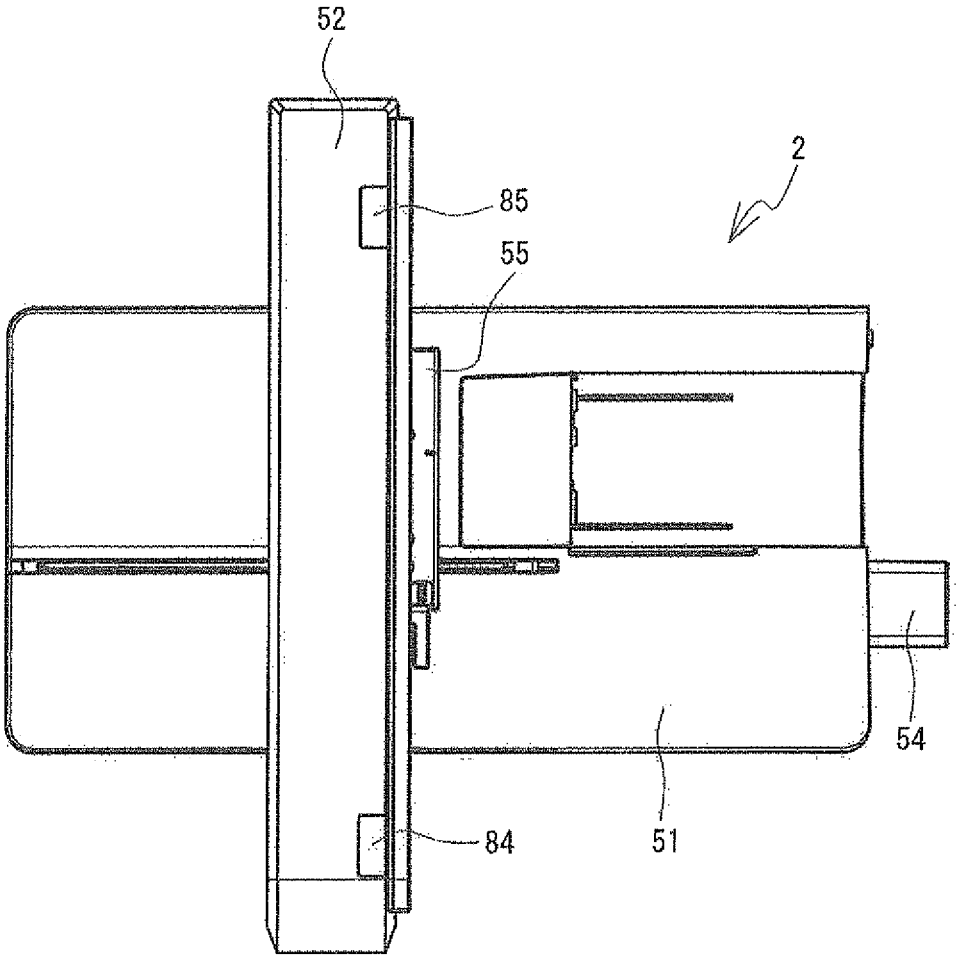


FIG. 10

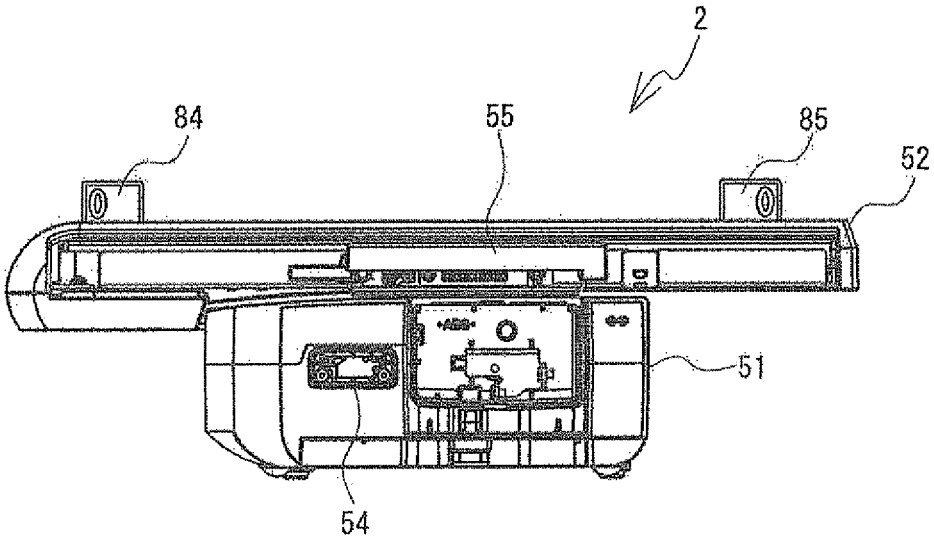


FIG. 11

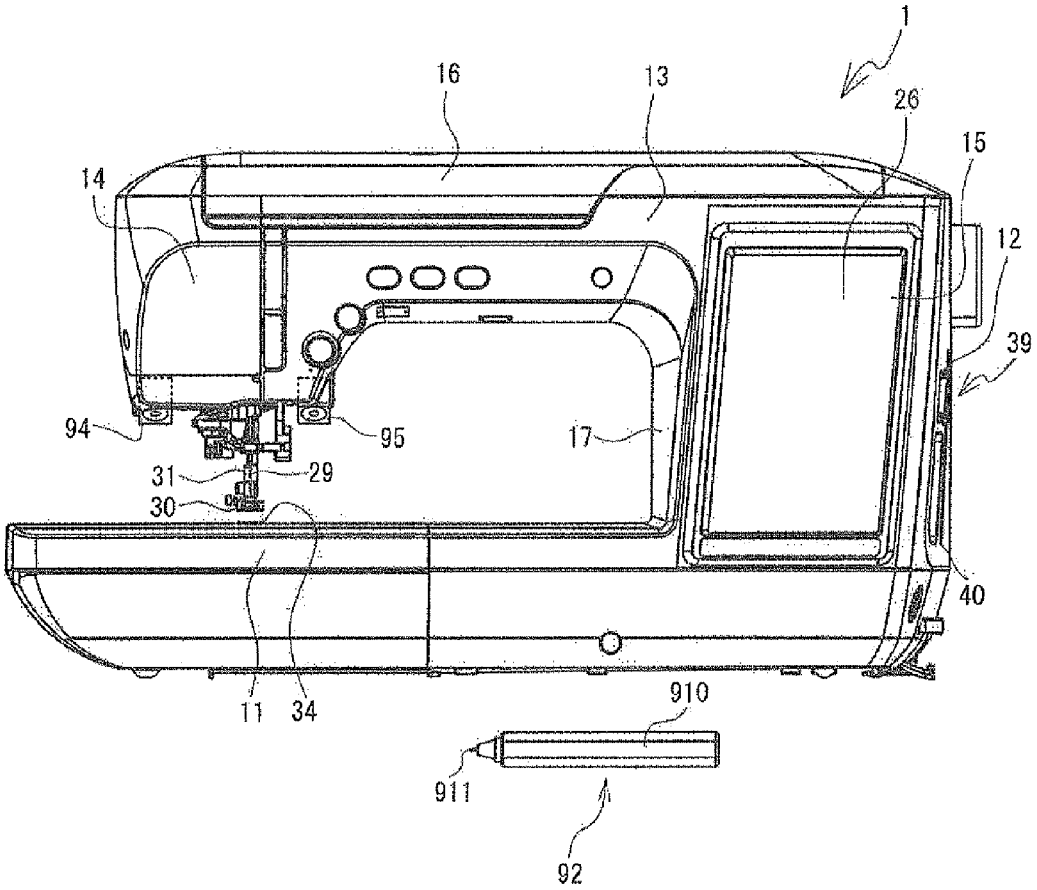


FIG. 12

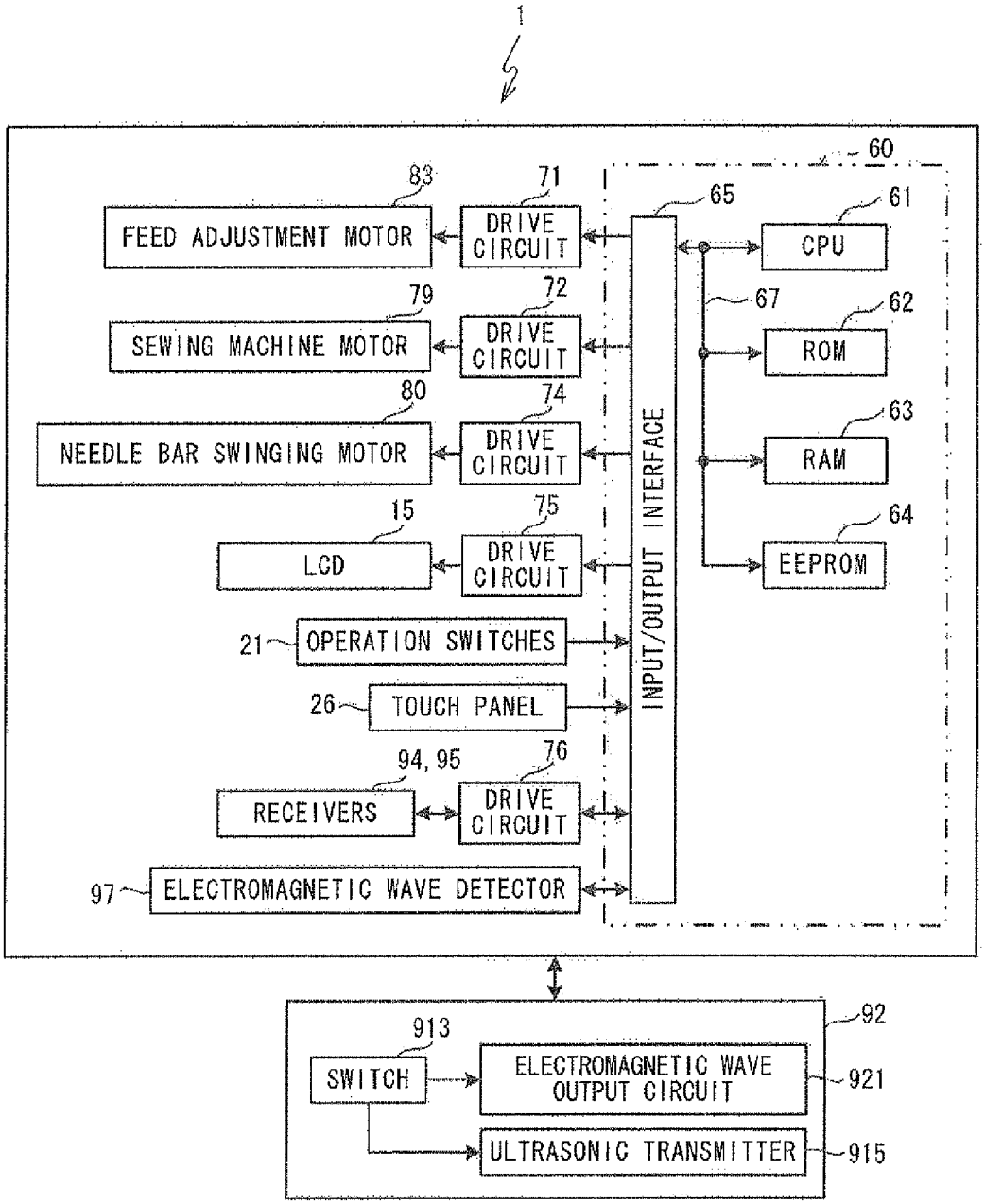

1
60
83
71
65
61
FEED ADJUSTMENT MOTOR
DRIVE CIRCUIT
CPU
79
72
67
62
SEWING MACHINE MOTOR
DRIVE CIRCUIT
ROM
80
74
63
NEEDLE BAR SWINGING MOTOR
DRIVE CIRCUIT
RAM
15
75
64
LCD
DRIVE CIRCUIT
EEPROM
21
OPERATION SWITCHES
26
TOUCH PANEL
INPUT/OUTPUT INTERFACE
94, 95
76
RECEIVERS
DRIVE CIRCUIT
97
ELECTROMAGNETIC WAVE DETECTOR
92
913
SWITCH
ELECTROMAGNETIC WAVE OUTPUT CIRCUIT
921
ULTRASONIC TRANSMITTER
915

FIG. 13

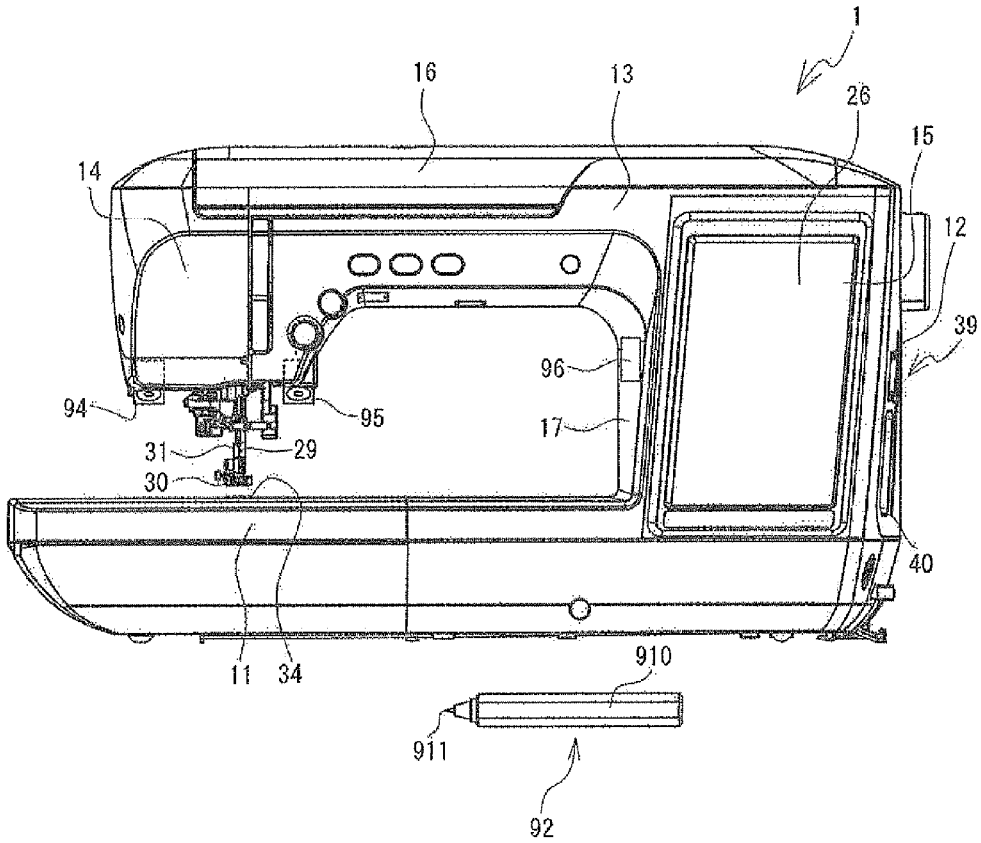


FIG. 14

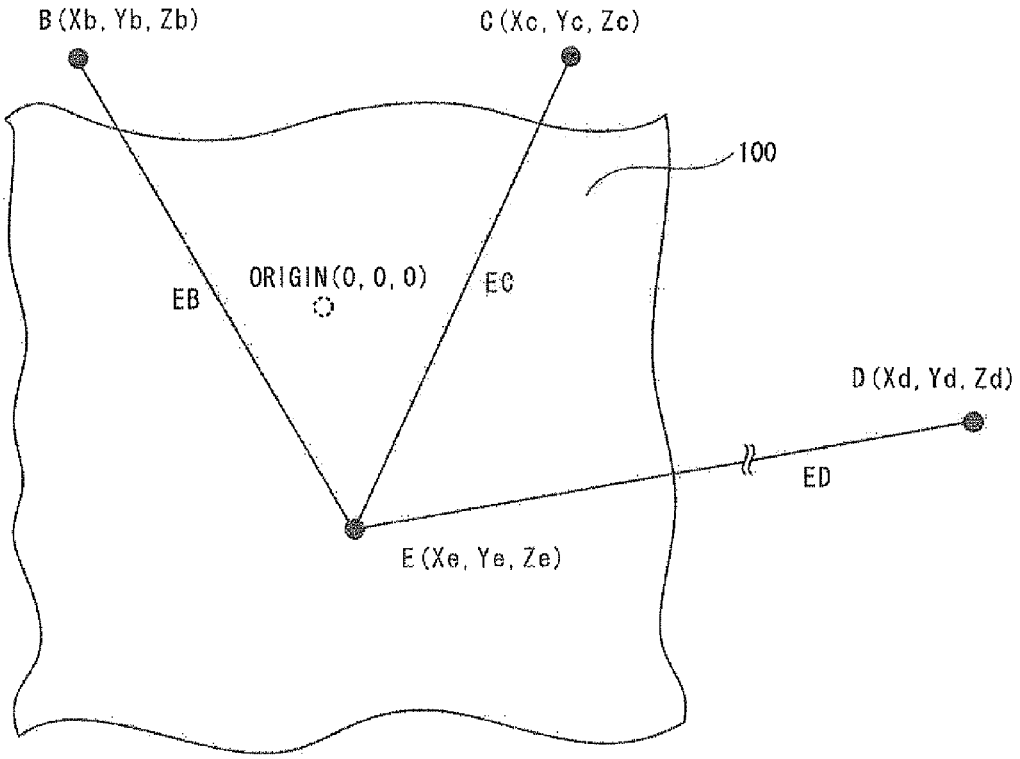


FIG. 15

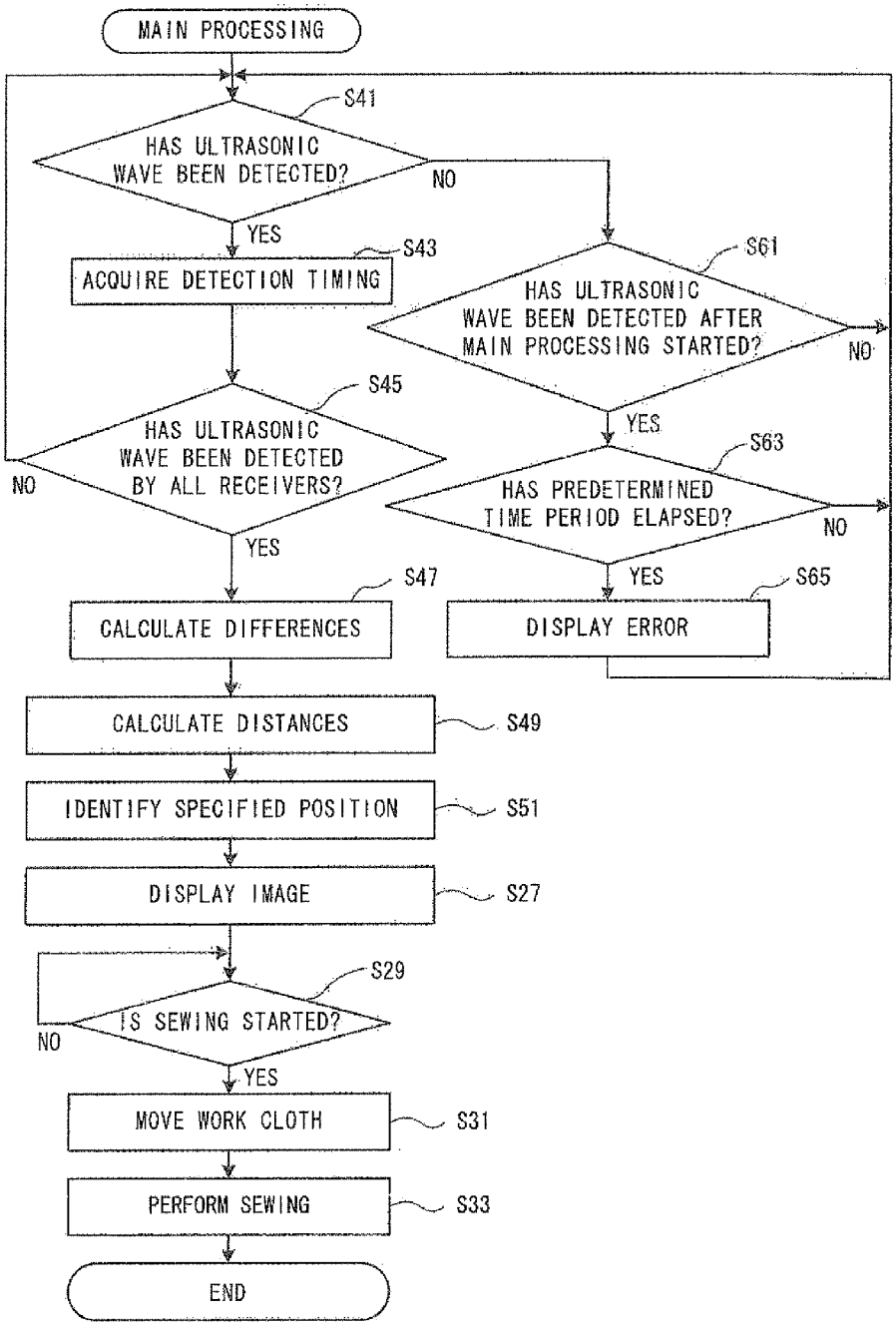
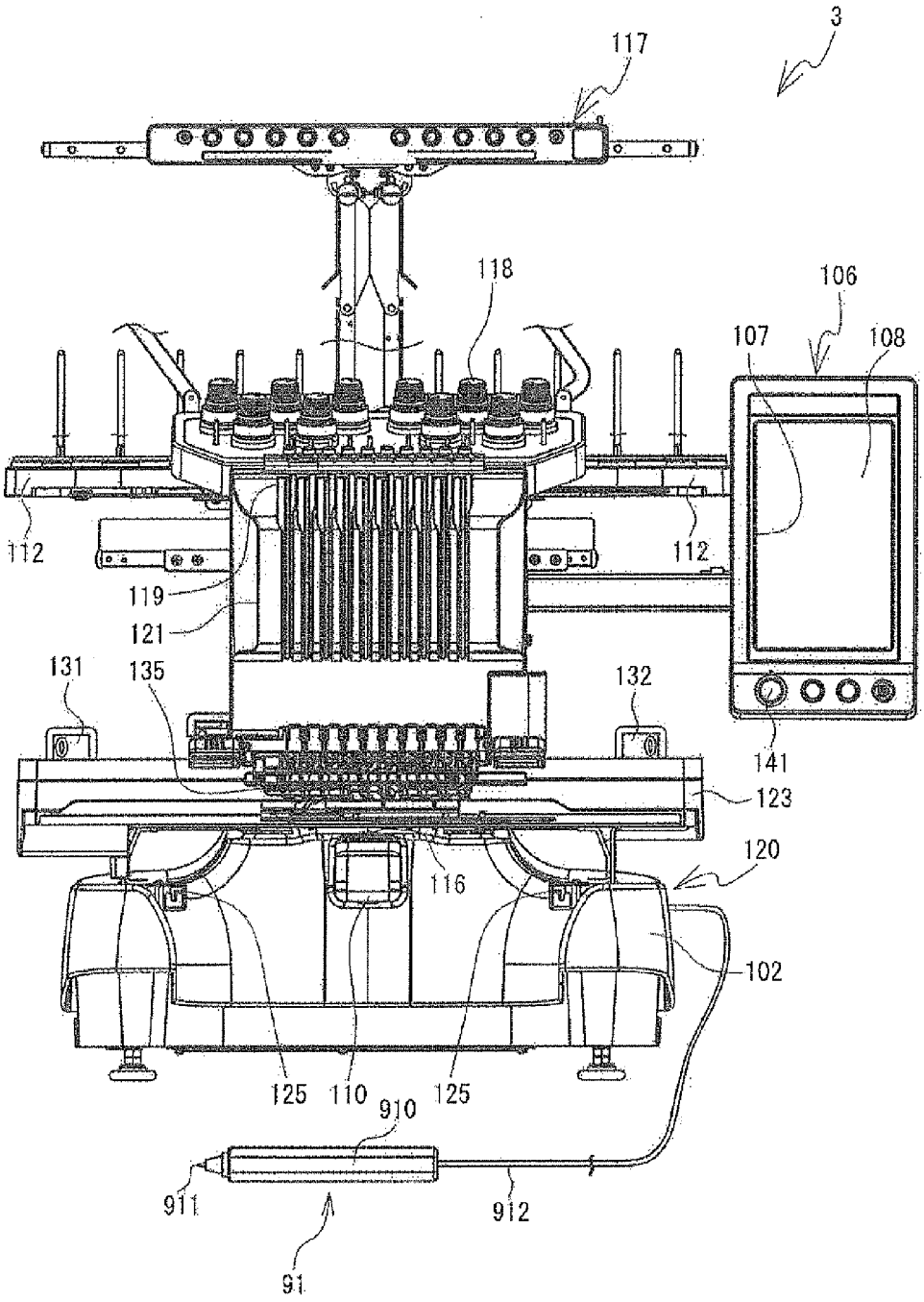

MAIN PROCESSING
S41
HAS ULTRASONIC WAVE BEEN DETECTED?
NO
YES
S43
ACQUIRE DETECTION TIMING
S61
HAS ULTRASONIC WAVE BEEN DETECTED AFTER MAIN PROCESSING STARTED?
NO
YES
S45
HAS ULTRASONIC WAVE BEEN DETECTED BY ALL RECEIVERS?
NO
YES
S63
HAS PREDETERMINED TIME PERIOD ELAPSED?
NO
YES
S47
CALCULATE DIFFERENCES
S65
DISPLAY ERROR
CALCULATE DISTANCES
S49
IDENTIFY SPECIFIED POSITION
S51
DISPLAY IMAGE
S27
S29
IS SEWING STARTED?
NO
YES
MOVE WORK CLOTH
S31
PERFORM SEWING
S33
END

FIG. 16


3
117
118
106
107
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910
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911
912
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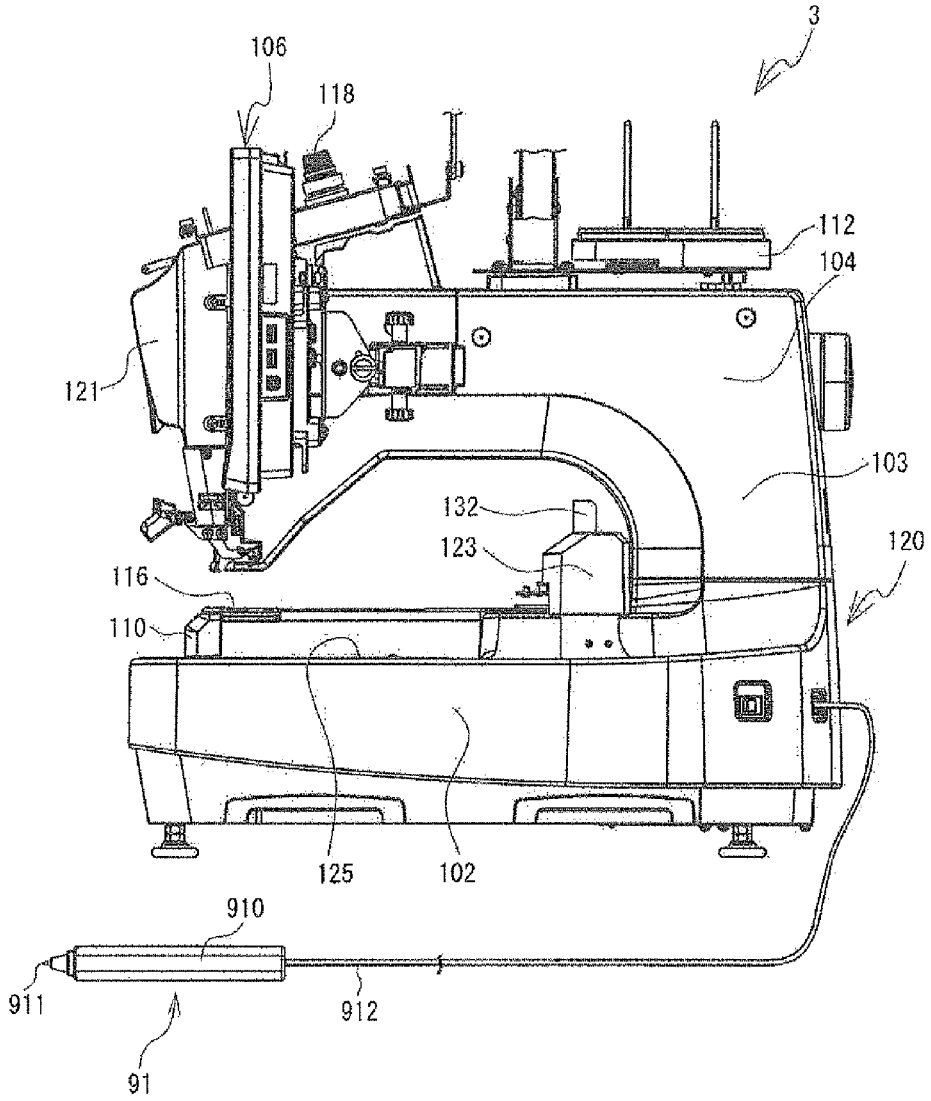
FIG. 17


3
106
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132
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116
110
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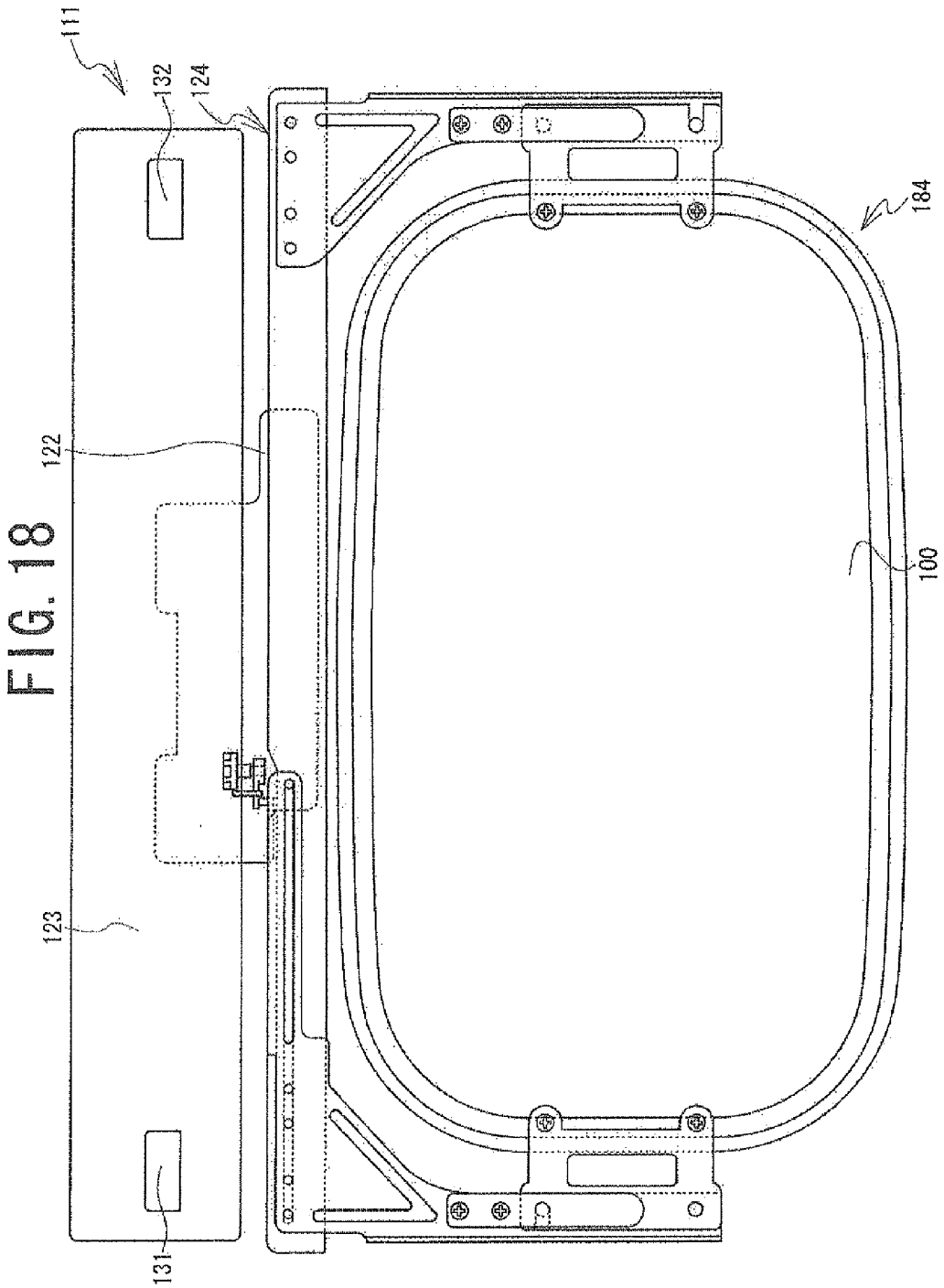
911
912
91

FIG. 18



SEWING MACHINE, EMBROIDERY UNIT, AND NON-TRANSITORY COMPUTER-READABLE MEDIUM STORING SEWING MACHINE CONTROL PROGRAM

CROSS-REFERENCE TO RELATED APPLICATION

This application claims priority to Japanese Patent Application No. 2012-055103 filed Mar. 12, 2012, the content of which is hereby incorporated herein by reference.

BACKGROUND

The present disclosure relates to a sewing machine, an embroidery unit, and a non-transitory computer-readable medium storing a sewing machine control program that allow sewing in a position specified on a work cloth.

A sewing machine is known that can easily set a sewing position and a sewing angle, at which a desired embroidery pattern is to be sewn, on a work cloth. For example, a known sewing machine includes an imaging portion. After a user affixes a marker to a specified position on the work cloth, an image of the marker may be captured by the imaging portion. The sewing machine may automatically set the sewing position and the sewing angle of the embroidery pattern based on the captured image of the marker.

SUMMARY

However, with the above-described sewing machine, it may be necessary to affix the marker to the work cloth. Further, after the sewing machine has set the sewing position and the sewing angle of the embroidery pattern, the user may need to remove the marker affixed to the work cloth before sewing is performed. Therefore, the operation may be troublesome for the user.

Embodiments of the broad principles derived herein provide a sewing machine, an embroidery unit, and a non-transitory computer-readable medium storing a sewing machine control program that enable easily setting a position, on a work cloth, at which sewing is performed.

Embodiments provide a sewing machine that includes at least one detecting portion, a processor, and a memory. The at least one detecting portion is configured to detect an ultrasonic wave that has been transmitted from a transmission source. The memory is configured to store computer-readable instructions that instruct the sewing machine to execute steps including identifying a position of the transmission source of the ultrasonic wave based on information pertaining to the ultrasonic wave that has been detected by the at least one detecting portion, and controlling sewing based on the position of the transmission source that has been identified.

Embodiments also provide an embroidery unit that can be attached to and detached from a bed of a sewing machine, and to which an embroidery frame can be attached, and that is configured to move the embroidery frame, the embroidery frame being configured to hold a work cloth. The embroidery unit includes at least one detecting portion and a notifying portion. The at least one detecting portion is configured to detect an ultrasonic wave that has been transmitted from a transmission source. The notifying portion is configured to notify the sewing machine of a detection timing at which the ultrasonic wave was detected by the at least one detecting portion. The embroidery unit is configured to move the work cloth based on a position of the transmission source of the ultrasonic wave that has been identified by the sewing machine based on the detection timing that has been notified by the notifying portion.

Embodiments further provide a non-transitory computer-readable medium storing a control program executable on a sewing machine. The program includes computer-readable instructions, when executed, to cause the sewing machine to perform the step of identifying, based on information pertaining to an ultrasonic wave that has been detected by at least one detecting portion of the sewing machine, a position of a transmission source of the ultrasonic wave. The at least one detecting portion is configured to detect the ultrasonic wave that has been transmitted from the transmission source. The program further includes computer-readable instructions, when executed, to cause the sewing machine to perform the step of controlling sewing based on the position of the transmission source that has been identified.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments will be described below in detail with reference to the accompanying drawings in which:

FIG. **1** is a front view of a sewing machine according to a first embodiment;

FIG. **2** is a perspective view of a receiver;

FIG. **3** is a front view of the receiver;

FIG. **4** is a cross-sectional view of the receiver taken along a line I-I shown in FIG. **3**, as seen in an arrow direction;

FIG. **5** is a block diagram showing an electrical configuration of the sewing machine and an ultrasonic pen according to the first embodiment;

FIG. **6** is a diagram illustrating a calculation method of specified coordinates E according to the first embodiment;

FIG. **7** is a flowchart showing main processing according to the first embodiment;

FIG. **8** is a front view of the sewing machine according to a second embodiment;

FIG. **9** is a plan view of an embroidery unit according to the second embodiment;

FIG. **10** is a right side view of the embroidery unit according to the second embodiment;

FIG. **11** is a front view of a sewing machine according to a third embodiment;

FIG. **12** is a block diagram showing an electrical configuration of the sewing machine and an ultrasonic pen according to the third embodiment;

FIG. **13** is a front view of a sewing machine according to a fourth embodiment;

FIG. **14** is a diagram illustrating a calculation method of specified coordinates E according to the fourth embodiment;

FIG. **15** is a flowchart showing main processing according to the fourth embodiment;

FIG. **16** is a front view of a sewing machine according to a fifth embodiment;

FIG. **17** is a right side view of a multi-needle sewing machine according to the fifth embodiment; and

FIG. **18** is a plan view of an embroidery frame movement mechanism according to the fifth embodiment.

DETAILED DESCRIPTION

First Embodiment

Hereinafter, a first embodiment will be explained with reference to the drawings. A configuration of a sewing machine **1** will be explained with reference to FIG. **1**. The near side, the far side, the upper side, the lower side, the left

side, and the right side of FIG. **1** are respectively defined as the front side, the rear side, the upper side, the lower side, the left side, and the right side of the sewing machine **1**. Specifically, a direction in which a pillar **12**, which will be described below, extends is the up-down direction of the sewing machine **1**. The longitudinal direction of a bed **11** and an arm **13** is the left-right direction of the sewing machine **1**. A surface on which a plurality of operation switches **21** are arranged is a front face of the sewing machine **1**.

The sewing machine **1** includes the bed **11**, the pillar **12**, the arm **13**, and a head **14**. The bed **11** is a base portion of the sewing machine **1** and extends in the left-right direction. The pillar **12** extends upward from the right end of the bed **11**. The arm **13** extends to the left from the upper end of the pillar **12** such that the arm **13** faces the bed **11**. The head **14** is provided on the left end of the arm **13**. A needle plate **34** is disposed on a top surface of the bed **11**. A feed dog, a feed mechanism, a shuttle mechanism (which are not shown in the drawings) and a feed adjustment motor **83** (refer to FIG. **5**) are provided below the needle plate **34** (namely, inside the bed **11**). The feed dog may be driven by the feed mechanism, and may feed a work cloth **100** (refer to FIG. **6**) by a specified feed distance. The feed adjustment motor **83** may adjust the feed distance of the feed dog.

A needle bar mechanism (not shown in the drawings), a needle bar swinging motor **80** (refer to FIG. **5**) and the like are provided on the head **14**. The needle bar mechanism may drive a needle bar **29** in the up-down direction. A sewing needle (not shown in the drawings) may be attached to the needle bar **29**. The needle bar swinging motor **80** may swing the needle bar **29** in the left-right direction. A receiver **94** is provided at the lower left end of the head **14**, on the rear side of a lower surface of the head **14**. A receiver **95** is provided at the lower right end of the head **14**, on the rear side of the lower surface of the head **14**. The receivers **94** and **95** are separated from each other in the left-right direction by the length of the head **14** in the left-right direction. The receivers **94** and **95** are configured to receive (detect) an ultrasonic wave. The receivers **94** and **95** have the same configuration. The receivers **94** and **95** will be described in more detail later.

A cover **16** to be opened and closed is provided on an upper portion of the arm **13**. A thread spool (not shown in the drawings) may be accommodated underneath the cover **16**, that is, substantially in a central portion within the arm **13**. An upper thread (not shown in the drawings) may be wound around the thread spool. The upper thread may be supplied from the thread spool, through a thread hook (not shown in the drawings), to the sewing needle attached to the needle bar **29**. The thread hook is provided on the head **14**. The needle bar mechanism, which is provided inside the head **14**, may drive the needle bar **29** such that the needle bar **29** is moved up and down. The needle bar mechanism may be driven by a sewing machine motor **79** (refer to FIG. **5**). A presser bar **31** extends downward from the lower end of the head **14**. A presser foot **30** may be detachably attached to the lower end of the presser bar **31**. The presser foot **30** may press down the work cloth **100**. The plurality of operation switches **21** are provided on a lower portion of the front face of the arm **13**. The plurality of operation switches **21** include a start/stop switch.

A liquid crystal display (LCD) **15** is provided on the front face of the pillar **12**. The LCD **15** may display images that include various types of items, such as a command, an illustration, a set value, a message, and the like. A touch panel **26** is provided on the front face of the LCD **15**. A user may perform an operation of pressing the touch panel **26** using a finger or a dedicated touch pen. Hereinafter, this operation is referred to as a "panel operation". The touch panel **26** detects a position pressed by the finger, the dedicated touch pen, or the like, and the sewing machine **1** (more specifically, a CPU **61** that will be described below) determines the item that corresponds to the detected position. In this manner, the sewing machine **1** recognizes the selected item. By the panel operation, the user can select a pattern to be sewn and a command to be executed.

Connectors **39** and **40** are provided on a right surface of the pillar **12**. An external storage device (not shown in the drawings), such as a memory card, can be connected to the connector **39**. The sewing machine **1** may read out pattern data and various programs from the external storage device connected to the connector **39**. A connector **916** may be connected to the connector **40**. The connector **916** is coupled to a cable **912** that extends from an ultrasonic pen **91** (which will be described below). The sewing machine **1** may supply electric power to the ultrasonic pen **91** via the connector **40**, the connector **916**, and the cable **912**, and may acquire an electrical signal output from the ultrasonic pen **91**.

The ultrasonic pen **91** will be explained. The ultrasonic pen **91** includes a pen body **910** and a pen tip **911**. The pen body **910** has a bar shape. The pen tip **911** is provided at the leading end of the pen body **910**. A point of the pen tip **911** is sharp. Normally, the pen tip **911** is in a protruding position in which the pen tip **911** protrudes slightly to the outside from the pen body **910**. On the other hand, when a force toward the pen body **910** acts on the pen tip **911**, the pen tip **911** is inserted into the pen body **910**. When the force acting on the pen tip **911** is released, the pen tip **911** returns to the original protruding position.

The ultrasonic pen **91** includes a switch **913** (refer to FIG. **5**), a signal output circuit **914** (refer to FIG. **5**), and an ultrasonic transmitter **915** (refer to FIG. **5**) inside the pen body **910**. The switch **913** is turned on and off in accordance with the position of the pen tip **911**. The switch **913** may switch output states of the signal output circuit **914** and the ultrasonic transmitter **915**.

When no force acts on the pen tip **911** (when the pen tip **911** is in the protruding position), the switch **913** is in an OFF state. When the switch **913** is in the OFF state, the signal output circuit **914** does not output an electrical signal and the ultrasonic transmitter **915** does not output an ultrasonic wave. On the other hand, when the user presses the pen tip **911** against an arbitrary position on the work cloth **100**, a force acts on the pen tip **911**. At this time, the pen tip **911** is inserted into the pen body **910** and the switch **913** is turned on. When the switch **913** is turned on, the signal output circuit **914** outputs an electrical signal to the sewing machine **1** via the cable **912**, and the ultrasonic transmitter **915** transmits an ultrasonic wave.

As will be described in detail below, the sewing machine **1** can receive (detect) the ultrasonic wave transmitted from the ultrasonic pen **91** using the receivers **94** and **95**. Based on the detected ultrasonic wave, the sewing machine **1** can identify a transmission source of the ultrasonic wave, namely, the position of the ultrasonic transmitter **915** provided in the ultrasonic pen **91**. The sewing machine **1** can perform sewing based on the identified position. Thus, the user can specify an arbitrary position on the work cloth **100** by pressing the pen tip **911** of the ultrasonic pen **91** on the work cloth **100** (touching the work cloth **100** with the pen tip **911**). As a result, it is possible to perform sewing in the specified position.

The receiver **94** will be explained with reference to FIG. **2** to FIG. **4**. The receiver **95** has the same configuration as that of the receiver **94**, so an explanation thereof is omitted. The lower left side, the upper right side, the upper left side, the lower right side, the upper side, and the lower side of FIG. **2**

are respectively defined as the front side, the rear side, the left side, the right side, the upper side, and the lower side of the receiver **94**.

As shown in FIG. **2** and FIG. **3**, the receiver **94** has a rectangular parallelepiped shape that is slightly longer in the up-down direction. An opening **941** is provided in the center of a lower end portion of the front face of the receiver **94**. The opening **941** has an elliptical shape that is long in the left-right direction. A wall **942** around the opening **941** is a tapered surface (an inclined surface) that becomes narrower from the outer side toward the inner side of a front surface of the receiver **94**. As shown in FIG. **4**, a substrate **943** and a microphone **944** are provided inside the receiver **94**. The microphone **944** is provided, inside the receiver **94**, behind the opening **941**. A connector **945** is mounted on an upper end of a rear surface of the substrate **943**. The connector **945** may be connected to a connector (not shown in the drawings) that is provided on the sewing machine **1**. An orientation of the receiver **94** is determined by a direction of the opening **941** in relation to the microphone **944**.

An electrical configuration of the sewing machine **1** and the ultrasonic pen **91** will be explained with reference to FIG. **5**. A control portion **60** of the sewing machine **1** includes a CPU **61**, a ROM **62**, a RAM **63**, an EEPROM **64**, and an input/output interface **65**, which are mutually connected via a bus **67**. The ROM **62** stores programs and data etc. that are used by the CPU **61** to execute processing. The EEPROM **64** stores data of various types of sewing patterns that are used for the sewing machine **1** to perform sewing.

The operation switches **21**, the touch panel **26**, and drive circuits **71**, **72**, **74**, **75**, and **76** are electrically connected to the input/output interface **65**. The drive circuits **71**, **72**, **74**, **75**, and **76** may respectively drive the feed adjustment motor **83**, the sewing machine motor **79**, the needle bar swinging motor **80**, the LCD **15**, the receiver **94**, and the receiver **95**. The drive circuit **76** includes an amplification circuit. The amplification circuit may amplify ultrasonic signals detected by the receivers **94** and **95**, and may transmit the amplified signals to the CPU **61**.

The electrical configuration of the ultrasonic pen **91** will be explained. The ultrasonic pen **91** includes the switch **913**, the signal output circuit **914**, and the ultrasonic transmitter **915**. The switch **913** is connected to the signal output circuit **914** and the ultrasonic transmitter **915**. The signal output circuit **914** can be connected to the input/output interface **65**. The signal output circuit **914** may output an electrical signal to the CPU **61** via the input/output interface **65**.

A method of identifying a position on the work cloth **100** specified using the ultrasonic pen **91** will be explained with reference to FIG. **6**. The user may cause the pen tip **911** of the ultrasonic pen **91** to touch the work cloth **100**, and thereby may specify a position on the work cloth **100** where sewing is to be performed by the sewing machine **1**. Hereinafter, a position on the work cloth **100** that is touched by the pen tip **911** of the ultrasonic pen **91** is also referred to as a specified position. As described below, the sewing machine **1** may identify a specified position by identifying a position of a transmission source of an ultrasonic wave. Therefore, strictly speaking, the position of the ultrasonic transmitter **915** provided in the ultrasonic pen **91** is identified, rather than the position on the work cloth **100** touched by the pen tip **911**. The pen tip **911** and the ultrasonic transmitter **915** are arranged very close to each other. Therefore, the position of the ultrasonic transmitter **915** may be assumed as the position on the work cloth **100** touched by the pen tip **911**, namely, the specified position. Hereinafter, the left-right direction, the front-rear direction, and the up-down direction of the sewing machine **1** are respectively defined as an X direction, a Y direction, and a Z direction. The left-right direction and the up-down direction of FIG. **6** respectively correspond to the X direction and the Y direction. A direction from the near side to the far side corresponds to the Z direction.

The sewing machine **1** identifies the specified position as coordinate information (an X coordinate, a Y coordinate, and a Z coordinate). Here, the coordinate origin (0, 0, 0) is defined as a center point of a needle hole. The needle hole is formed in the needle plate **34** (refer to FIG. **1**), and is a hole through which the sewing needle may pass. The center point of the needle hole is a needle drop point, which will be described below. The Z coordinate of a top surface of the needle plate **34** is 0. Coordinates B that indicate the position of the receiver **94** are denoted by (Xb, Yb, Zb). Coordinates C that indicate the position of the receiver **95** are denoted by (Xc, Yc, Zc). Coordinates E that indicate the specified position are denoted by (Xe, Ye, Ze), The Z coordinate of the receivers **94** and **95** indicates the height of the receivers **94** and **95** with respect to the top surface of the needle plate **34**. The coordinates B (Xb, Yb, Zb) and the coordinates C (Xc, Yc, Zc) are stored in advance in the ROM **62**. Hereinafter, the coordinates E are also referred to as "specified coordinates E". A distance between the specified coordinates E and the coordinates B is referred to as a "distance EB". A distance between the specified coordinates E and the coordinates C is referred to as a "distance EC".

The distances EB and EC can be expressed by the coordinates B, C, and E based on the Pythagorean theorem. The distance EB and the coordinates B, C, and E satisfy a relationship of Formula (1) below. In a similar manner, the distance EC and the coordinates B, C, and E satisfy a relationship of Formula (2) below.

$$(Xb-Xe)^2+(Yb-Ye)^2+(Zb-Ze)^2=(EB)^2 \quad \text{Formula (1)}$$

$$(Xc-Xe)^2+(Yc-Ye)^2+(Zc-Ze)^2=(EC)^2 \quad \text{Formula (2)}$$

Formula (1) is the same as the equation of a spherical surface (whose radius is the distance EB), the origin of which is the coordinates B and on which the specified coordinates E is. In a similar manner, Formula (2) is the same as the equation of a spherical surface (whose radius is the distance EC), the origin of which is the coordinates C and on which the coordinates E is.

The speed at which an ultrasonic wave travels is assumed to be a sonic velocity V. A time required from when the ultrasonic wave is transmitted from the ultrasonic pen **91** at the specified coordinates E to when the ultrasonic wave reaches the receiver **94** is referred to as a propagation time Tb. A time required from when the ultrasonic wave is transmitted from the ultrasonic pen **91** at the specified coordinates E to when the ultrasonic wave reaches the receiver **95** is referred to as a propagation time Tc. In this case, the distances EB and EC are expressed by the following Formulas (3) and (4).

$$EB=V\times Tb \quad \text{Formula (3)}$$

$$EC=V\times Tc \quad \text{Formula (4)}$$

The following Formulas (5) and (6) are obtained by substituting Formulas (3) and (4) into Formulas (1) and (2) described above.

$$(Xb-Xe)^2+(Yb-Ye)^2+(Zb-Ze)^2=(V\times Tb)^2 \quad \text{Formula (5)}$$

$$(Xc-Xe)^2+(Ye-Ye)^2+(Zc-Ze)^2=(V\times Tc)^2 \quad \text{Formula (6)}$$

In Formulas (5) and (6), the coordinates B (Xb, Yb, Zb), the coordinates C (Xc, Yc, Zc) and the sonic velocity V are known values and stored in advance in the ROM **62**. The propagation

time Tb and the propagation time Tc are each identified by calculating a difference between a transmission timing T1 and a detection timing T2. The transmission timing T1 is a timing at which the ultrasonic wave is transmitted from the ultrasonic transmitter **915** of the ultrasonic pen **91**. The detection timing T2 is a timing at which the ultrasonic wave is detected by each of the receivers **94** and **95**. The thickness of the work cloth **100** is small enough to be ignored, in comparison to the values Xe and Ye. Therefore, the value Ze of the specified coordinates E (Xe, Ye, Ze) can be deemed to be zero. Thus, the values Xe and Ye can be calculated by solving the simultaneous equations represented by Formulas (5) and (6). Here, taking orientations of the receivers **94** and **95** into account, the specified coordinates E (Xe, Ye, Ze (=0)) on the work cloth **100** that are specified using the ultrasonic pen **91** can be determined.

It is preferable that the receivers **94** and **95** be provided in positions of the sewing machine **1** that satisfy the following conditions (A) to (E). In an explanation of the conditions (A) to (E), the receivers **94** and **95** are referred to as receivers **93** for convenience of the explanation.

(A) An object is unlikely to enter between the ultrasonic pen **91** and the receivers **93**.

(B) The receivers **93** are separated from each other to some extent.

(C) The distance, in the X direction and the Y direction, from the needle hole (the origin) of the needle plate **34** to the receivers **93** is large.

(D) The distance from the needle hole (the origin) to the receivers **93** is not extremely large.

(E) The receivers **93** are provided above the top surface of the bed **11**. Specifically, the receivers **94** are provided above the work cloth **100** placed on the bed **11**.

The reasons are as follows.

The condition (A) is set because if an object enters between the ultrasonic pen **91** and the receivers **93**, the receivers **93** may not receive the ultrasonic wave transmitted from the ultrasonic pen **91**. The object may be, for example, a hand or an arm of the user. For example, there is a possibility that the hand or the arm enters between the pen tip **911** and the receivers **93** when the user who holds the ultrasonic pen **91** in the user's hand is specifying the specified position. In this case, the ultrasonic wave transmitted from the ultrasonic pen **91** may be shielded by the hand or the arm. Therefore, a case may occur in which the receivers **93** cannot receive the ultrasonic wave. For that reason, it is preferable that the receivers **93** be provided in positions where the hand or the arm of the user does not enter between the ultrasonic pen **91** and the receivers **93** when the user is performing an operation using the ultrasonic pen **91**.

The reason for setting the condition (B) is as follows. When the simultaneous equations represented by Formulas (5) and (6) are solved, if the difference between the coordinates B and C is small, the results of Formulas (5) and (6) are close to each other. In this case, an error of the calculated specified coordinates E may become large.

The reason for setting the condition (C) is as follows. As the distance from the origin to the receivers **93** in the X direction and the Y direction increases, the Z-coordinate values of the coordinates B and C become relatively smaller than the X-coordinate values and the Y-coordinate values of the coordinates B and C. Therefore, it is possible to reduce an influence on a calculation result caused by the thickness of the work cloth **100**.

The reason for setting the condition (D) is as follows. If the distance from the origin to the receivers **93** is extremely large, the ultrasonic wave transmitted from the ultrasonic pen **91** may be attenuated before the ultrasonic wave reaches the receivers **93**. Therefore, it is difficult for the receivers **93** to accurately receive the ultrasonic wave.

The reason for setting the condition (E) is that the pen tip **911** of the ultrasonic pen **91** may come into contact with the top surface of the work cloth **100** that is placed on the bed **11**. It is preferable that the receivers **93** can accurately receive the ultrasonic wave transmitted from the ultrasonic pen **91** that is in contact with the top surface of the work cloth **100**, Therefore, it is preferable that the receivers **93** be provided above the top surface of the bed **11**.

In the first embodiment, as shown in FIG. **1**, the receiver **94** is provided at the lower left end of the head **14** and the receiver **95** is provided at the lower right end of the head **14**. The position on the work cloth **100** that can be easily specified by the user while the user is holding the ultrasonic pen **91** in the user's hand may be a position on the front side with respect to the needle hole. Thus, the condition (A) is substantially satisfied. The distance between the receivers **94** and **95** is almost the same as the length of the head **14** in the left-right direction. Therefore, the receivers **94** and **95** are sufficiently separated from each other, and the condition (B) is satisfied. The receivers **94** and **95** are provided on the rear side of the lower surface of the head **14**. Thus, the distances from the origin to the receivers **94** and **95** in the X direction and the Y direction are larger than when the receivers **94** and **95** are provided substantially in the center, in the front-rear direction, of the lower surface of the head **14**. Thus, the condition (C) is satisfied. The distances from the origin to the receivers **94** and **95** are not extremely large. Thus, the condition (D) is satisfied. The receivers **94** and **95** are provided above the top surface of the bed **11**. Thus, the condition (E) is satisfied. In this manner, in the first embodiment, the positions in which the receivers **94** and **95** are provided satisfy all the conditions (A) to (E). Therefore, the sewing machine **1** can calculate the specified coordinates E more precisely.

Processing that is performed by the CPU **61** of the sewing machine **1** to identify the specified position will be specifically explained with reference to FIG. **7**. Main processing is performed by the CPU **61** in accordance with the program stored in the ROM **62**. For example, when a command to perform sewing is input by a panel operation, the CPU **61** may start the main processing.

The CPU **61** determines whether an electrical signal output from the signal output circuit **914** of the ultrasonic pen **91** has been detected via the cable **912** (step S**11**). If the electrical signal has not been detected (NO at step S**11**), the processing returns to step S**11**. It is assumed that the user specifies an arbitrary position on the work cloth **100** using the ultrasonic pen **91** and the pen tip **911** of the ultrasonic pen **91** comes into contact with the work cloth **100**. The pen tip **911** of the ultrasonic pen **91** may be inserted into the pen body **910** and the switch **913** may be turned on. The signal output circuit **914** may output an electrical signal. The CPU **61** may detect the electrical signal (YES at step S**11**). In a case where the switch **913** of the ultrasonic pen **91** is turned on, the ultrasonic transmitter **915** transmits an ultrasonic wave at the same time as when the signal output circuit **914** outputs the electrical signal. However, the propagation speed of the electrical signal is significantly higher than the propagation speed of the ultrasonic wave, and the electrical signal reaches the CPU **61** substantially at the same timing as the timing at which the switch **913** is turned on.

If the CPU **61** has detected the electrical signal output from the signal output circuit **914** of the ultrasonic pen **91** (YES at step S**11**), the CPU **61** identifies a time at which the electrical signal is detected. The CPU **61** acquires the identified time as

the transmission timing T1 of the ultrasonic wave (step S13). The CPU **61** stores the acquired transmission timing T1 in the RAM **63**.

The CPU **61** determines whether the ultrasonic wave transmitted from the ultrasonic pen **91** has been detected via at least one of the receivers **94** and **95** (step S15). If the ultrasonic wave has not been detected via at least one of the receivers **94** and **95** (NO at step S15), the CPU **61** determines whether or not a predetermined time period (for example, one second) has elapsed (step S35). If the predetermined time period has not elapsed (NO at step S35), the processing returns to step S15. The CPU **61** stands by for the predetermined time period until at least one of the receivers **94** and **95** detect the ultrasonic wave.

Here, it is assumed that the ultrasonic wave transmitted from the ultrasonic transmitter **915** of the ultrasonic pen **91** is shielded by, for example, the hand or the arm of the user, the work cloth **100**, or the like and does not reach the receivers **94** and **95**. In this manner, if the predetermined time period has elapsed without detecting the ultrasonic wave by at least one of the receivers **94** and **95** (YES at step S35), the CPU **61** displays on the LCD **15** an error message indicating that the ultrasonic wave has not been detected (step S37). In a case where the user sees the error message, the user may once again specify an arbitrary position on the work cloth **100** using the ultrasonic pen **91**. The processing returns to step S11 to re-detect the electrical signal output from the signal output circuit **914** of the ultrasonic pen **91**.

If the CPU **61** detects the ultrasonic wave via at least one of the receivers **94** and **95** within the predetermined time period from the detection of the electrical signal (YES at step S15), the CPU **61** identifies a time at which the ultrasonic wave is detected. The CPU **61** acquires the identified time as the detection timing T2 (step S17). The CPU **61** stores the acquired detection timing T2 in the RAM **63**.

The CPU **61** determines whether both the receivers **94** and **95** have detected the ultrasonic wave (step S19). If one of the receivers **94** and **95** has not detected the ultrasonic wave (NO at step S19), the processing returns to step S15. If both the receivers **94** and **95** have detected the ultrasonic wave (YES at step S19), the CPU **61** calculates the propagation time Tb and the propagation time Tc (step S21). The CPU **61** calculates the propagation time Tb and the propagation time Tc by subtracting the transmission timing T1 from the detection timing T2.

The CPU **61** multiplies the calculated Tb and Tc by the sonic velocity V and thereby calculates the distances EB and EC (step S23) (refer to Formulas (3) and (4)). The CPU **61** substitutes the coordinates B (Xb, Yb, Zb), the coordinates C (Xc, Ye, Ze), and the distances EB and EC into Formulas (5) and (6), and solves the simultaneous equations. Thus, the CPU **61** calculates the specified coordinates E (Xe, Ye, Ze (=0)). In this manner, the CPU **61** identifies the position specified using the ultrasonic pen **91**, namely, the specified position (step S25).

The CPU **61** displays, on the LCD **15**, a display image that shows a relationship between the specified position, which is indicated by the specified coordinates E (Xe, Ye, Ze), and the work cloth **100** (step S27). The CPU **61** determines whether the start/stop switch, which is one of the operation switches **21**, has been pressed (step S29). If the start/stop switch has not been pressed (NO at step S29), the processing returns to step S29. If the start/stop switch has been pressed (YES at step S29), the CPU **61** drives the feed dog and moves the work cloth such that the position indicated by the X-coordinate "Xe" and the Y-coordinate "Ye" of the specified coordinates E calculated at step S25 matches the needle drop point (step S31). Then, the CPU **61** starts sewing (step S33). In this manner, sewing is started from the position on the work cloth **100** specified using the ultrasonic pen **91**, namely, the specified position. When the sewing is complete, the main processing ends. The needle drop point is a point at which the sewing needle may penetrate the work cloth **100**, namely, the center point of the needle hole formed in the needle plate **34**.

As explained above, in a case where the user specifies an arbitrary position on the work cloth **100** using the ultrasonic pen **91**, the sewing machine **1** can identify the specified position and start sewing. In this manner, the user can easily and appropriately specify a position on the work cloth **100** using the ultrasonic pen **91**. The sewing machine **1** can detect the ultrasonic wave using the plurality of receivers **94** and **95**, and calculate the specified coordinates E based on the transmission timing T1 and the detection timings T2. Thus, the sewing machine **1** can accurately identify the specified position.

The present disclosure is not limited to the first embodiment and various modifications may be made. The positions in which the receivers **94** and **95** are provided are not limited to the head **14** of the sewing machine **1**. For example, the receivers **94** and **95** may be provided on at least one of the presser foot **30** and the presser bar **31**. More specifically, the receiver **94** may be provided on the left side of the presser foot **30** or the presser bar **31** and the receiver **95** may be provided on the right side of the presser foot **30** or the presser bar **31**.

For example, the receiver **94** may be provided on one of the head **14**, the presser foot **30**, and the presser bar **31**, and the receiver **95** may be provided on the arm portion **13** side of the pillar **12**, namely, on any part of a left surface **17** (refer to FIG. **1**) of the pillar **12**. In this case, the opening **941** of the receiver **95** is provided such that the opening **941** faces to the left. In this case, the distance between the receivers **94** and **95** is larger than when the receiver **95** is provided on the head **14** (refer to condition (B)). The distance, in the X direction and the Y direction, from the needle hole (the origin) of the needle plate **34** to the receiver **95** also increases (refer to condition (C)). Further, the receivers **94** and **95** are provided above the top surface of the bed **11** (refer to condition (E)). In this manner, the positions in which the receivers **94** and **95** are provided satisfy a plurality of conditions included in the conditions (A) to (E), in a similar manner to the first embodiment. Therefore, the sewing machine **1** can precisely calculate the specified coordinates E. Further, particularly in this case, it is possible to increase the distance between the receivers **94** and **95**.

The combinations of the positions of the receivers **94** and **95** are not limited to those of the first embodiment and the modified examples described above. In a case where the receivers **94** and **95** are provided on the head **14**, the positions of the receivers **94** and **95** are not limited to the rear side of the lower surface of the head **14**. For example, the receivers **94** and **95** may be provided on the front side of the lower surface of the head **14**, substantially in the center in the front-rear direction of the lower surface of the head **14**, or the like. In a case where the receiver **95** is provided on the left surface **17** of the pillar **12**, the height at which the receiver **95** is disposed is not particularly limited. However, it is preferable that the receiver **95** be disposed in a lower position in order to reduce an influence caused by approximating the value Ze in Formulas (5) and (6) to zero.

The receivers **94** and **95** may be provided on a part other than the head **14**, the presser foot **30**, the presser bar **31**, and the left surface **17** of the pillar **12**. For example, the receivers **94** and **95** may be provided on a lower side surface of the arm **13**, a front surface or a rear surface of the head **14**, or an upper surface of the bed **11** at the left end of the bed **11**. The

ultrasonic pen **91** need not necessarily be attached to the sewing machine **1**. The sewing machine **1** may detect an ultrasonic wave output from a known device configured to output an ultrasonic wave, and may identify a position of the transmission source of the ultrasonic wave as the specified position.

Second Embodiment

A second embodiment will be explained. In the second embodiment, as shown in FIG. **8** to FIG. **10**, receivers **84** and **85** are provided not on the sewing machine **1**, but on an embroidery unit **2**, which can be attached to and detached from the bed **11** of the sewing machine **1**. FIG. **9** and FIG. **10** show the embroidery unit **2** that is not attached to the sewing machine **1**. The embroidery unit **2** includes a body portion **51** and a carriage **52**.

As shown in FIG. **9** and FIG. **10**, a connection portion **54** is provided on a right surface of the body portion **51** of the embroidery unit **2**. In a state in which the embroidery unit **2** is attached to the sewing machine **1**, the connection portion **54** is connected to a connection receiving portion (not shown in the drawings) of the sewing machine **1**, and thus the embroidery unit **2** and the sewing machine **1** are electrically connected.

The carriage **52** is provided on the upper side of the body portion **51**. The carriage **52** has a rectangular parallelepiped shape that is long in the front-rear direction. The carriage **52** includes a frame holder **55**, a Y axis movement mechanism (not shown in the drawings), and a Y axis motor (not shown in the drawings). The frame holder **55** is a holder to which an embroidery frame (not shown in the drawings) can be detachably attached. The holder **55** is provided on a right surface of the carriage **52**. The embroidery frame is a known frame that includes an inner frame and an outer frame. The embroidery frame may clamp and hold the work cloth **100**. The work cloth **100** held by the embroidery frame may be arranged on the top surface of the bed **11** and below the needle bar **29** and the presser foot **30**. The Y axis movement mechanism may move the frame holder **55** in the front-rear direction (the Y direction). Along with the movement of the frame holder **55** in the front-rear direction, the work cloth **100** held by the embroidery frame may be moved in the front-rear direction. The Y axis motor may drive the Y axis movement mechanism. The CPU **61** (refer to FIG. **5**) controls the Y axis motor.

An X axis movement mechanism (not shown in the drawings) and an X axis motor (not shown in the drawings) are provided inside the body portion **51**. The X axis movement mechanism may move the carriage **52** in the left-right direction (the X direction). Along with the movement of the carriage **52** in the left-right direction, the work cloth **100** held by the embroidery frame may be moved in the left-right direction. The X axis motor may drive the X axis movement mechanism. The CPU **61** controls the X axis motor.

The receiver **84** is provided at the front end of an upper surface of the carriage **52**. The receiver **85** is provided at the rear end of the upper surface of the carriage **52**. The receivers **84** and **85** receive are configured to an ultrasonic wave. The receivers **84** and **85** have the same configuration as the receivers **94** and **95**. The embroidery frame attached to the frame holder **55** is located at the right of the right surface of the carriage **52**, Therefore, the receivers **84** and **85** are located above the position of the carriage **52** where the embroidery frame can be attached. Thus, the receivers **84** and **85** are located above the body portion **51** of the embroidery unit **2**. When the embroidery unit **2** is attached to the bed **11** of the sewing machine **1**, the receivers **84** and **85** are located above the bed **11**. Openings of the receivers **84** and **85** are directed to the right. In a case where the receivers **84** and **85** receive an ultrasonic wave, the receivers **84** and **85** each transmit an electrical signal to the sewing machine **1**. The CPU **61** may receive the electrical signals from the receivers **84** and **85**, and thereby may detect the ultrasonic wave transmitted from the ultrasonic pen **91**.

Processing that is performed by the CPU **61** of the sewing machine **1** to identify the specified position will be explained with reference to FIG. **7**. In a case where the CPU **61** detects an electrical signal output from the signal output circuit **914** of the ultrasonic pen **91** via the cable **912** (YES at step S**11**), the CPU **61** acquires the transmission timing T**1** (step S**13**). In a case where the CPU **61** receives the electrical signal from each of the receivers **84** and **85** (YES at step S**15**), the CPU **61** identifies a time at which the electrical signal is received from the receiver **84** and a time at which the electrical signal is received from the receiver **85**, and acquires the identified times as the detection timings T**2** (step S**17**). The CPU **61** calculates the specified coordinates E and identifies the specified position (steps S**21** to S**25**). The CPU **61** controls the X axis motor and the Y axis motor, and thereby moves the embroidery frame such that the position of the specified coordinates E on the work cloth **100** matches the needle drop point (step S**31**). Next, the CPU **61** starts sewing on the work cloth **100**. The CPU **61** drives the needle bar **29** and the shuttle mechanism (not shown in the drawings) simultaneously with the embroidery frame being moved in the left-right direction (the X direction) and the front-rear direction (the Y direction). The sewing needle attached on the needle bar **29** sews an embroidery pattern on the work cloth **100** held by the embroidery frame. In this manner, the embroidery pattern is sewn in the specified position on the work cloth **100** (step S**33**).

In the second embodiment, the receivers **84** and **85** are respectively provided at the front end and the rear end of the carriage **52**, as shown in FIG. **9** and FIG. **10**. Therefore, when the embroidery unit **2** is attached to the bed **11**, all the above-described conditions (A) to (E) are satisfied. The ultrasonic wave transmitted from the ultrasonic pen **91** when the pen tip **911** is in contact with the work cloth **100** may be not shielded by the hand or the arm of the user (refer to condition (A)). The distance between the receivers **84** and **85** is separated by a length, in the front-rear direction, of the carriage **52**. As a result, the receivers **84** and **85** are sufficiently separated from each other (refer to condition (B)). The distances, in the X direction and the Y direction, from the needle hole (the origin) of the needle plate **34** to the receivers **84** and **85** are larger than when the receivers **84** and **85** are provided on the head **14**, the presser foot **30** or the presser bar **31** of the sewing machine **1** (refer to condition (C)). The distances from the origin to the receivers **84** and **85** are not extremely large (refer to condition (D)). The receivers **84** and **85** are provided above the body portion **51** of the embroidery unit **2**. Therefore, the receivers **84** and **85** are located above the bed **11** (refer to condition (E)). Specifically, the receivers **84** and **85** are provided above the work cloth **100** held by the embroidery frame. Therefore, the sewing machine **1** can calculate the specified coordinates E more precisely and perform sewing on the work cloth **100**. Further, the height from the top surface of the bed **11** to the receivers **84** and **85** is low. If the height from the top surface of the bed **11** to the receivers **84** and **85** is high, there is a possibility that the influence on a calculation result caused by the thickness of the work cloth **100** increases. If the height from the top surface of the bed **11** to the receivers **84** and **85** is low, the influence caused by approximating the value Ze in

Formulas (5) and (6) to zero may decrease. Therefore, the error of the calculated specified coordinates E may become small.

In the second embodiment, the receivers **84** and **85** may be provided on a part other than the top surface of the carriage **52**. For example, the receiver **84** may be provided on a front surface of the carriage **52** and the receiver **85** may be provided on a rear surface of the carriage **52**. For example, the receiver **84** may be provided at the front side of the right surface of the carriage **52**, and the receiver **85** may be provided at the rear side of the right surface of the carriage **52**.

Third Embodiment

A third embodiment will be explained. As shown in FIG. **11**, the sewing machine **1** of the third embodiment is different from the sewing machine **1** of the first embodiment in that the sewing machine **1** is provided with an ultrasonic pen **92** that is not connected to the sewing machine **1** via a cable. Instead of the signal output circuit **914** (refer to FIG. **5**), an electromagnetic wave output circuit **921** (refer to FIG. **12**) is provided inside the ultrasonic pen **92**. The ultrasonic pen **92** accommodates a battery (not shown in the drawings). The ultrasonic pen **92** may be driven by the battery. The electromagnetic wave output circuit **921** may output an electromagnetic wave signal of a predetermined frequency. When the switch **913** (refer to FIG. **12**) is in an OFF state, the electromagnetic circuit **921** does not output the electromagnetic wave signal. When the switch **913** is turned on, the electromagnetic wave output circuit **921** outputs the electromagnetic wave signal. The CPU **61** may receive the electromagnetic wave signal output from the electromagnetic wave output circuit **921** using an electromagnetic wave detector **97** (refer to FIG. **12**). The electromagnetic wave detector **97** is provided inside the sewing machine **1**. The position of the electromagnetic detector **97** is not limited to the inside of the sewing machine **1** as long as the sewing machine **1** can receive the electromagnetic wave signal.

An electrical configuration of the sewing machine **1** and the ultrasonic pen **92** according to the third embodiment will be explained with reference to FIG. **12**. The third embodiment is different from the first embodiment in that the ultrasonic pen **92** includes the electromagnetic wave output circuit **921** and in that the sewing machine **1** includes the electromagnetic wave detector **97**. The electromagnetic wave output circuit **921** is connected to the switch **913**. The electromagnetic detector **97** is connected to the input/output interface **65**. When the electromagnetic wave detector **97** receives the electromagnetic wave signal output from the electromagnetic wave output circuit **921** of the ultrasonic pen **92**, the electromagnetic wave detector **97** outputs a signal to the CPU **61** via the input/output interface **65**.

Main processing according to the third embodiment will be explained with reference to FIG. **7**. At step S**11**, the CPU **61** determines whether the electromagnetic wave detector **97** has detected the electromagnetic wave signal output from the electromagnetic wave output circuit **921** of the ultrasonic pen **92**, instead of detecting the electrical signal output from the signal output circuit **914** of the ultrasonic pen **91** (step S**11**). If the electromagnetic wave detector **97** has not detected the electromagnetic wave signal (NO at step S**11**), the processing returns to step S**11**. If the electromagnetic wave detector **97** has detected the electromagnetic wave signal (YES at step S**11**), the CPU **61** identifies a time at which the electromagnetic wave signal has been detected. The CPU **61** acquires the identified time as the transmission timing T**1** of the ultrasonic wave (step S**13**). The CPU **61** stores the acquired transmission timing T**1** in the RAM **63**. Processing from steps S**15** to S**33** is performed in the same manner as in the first embodiment, and an explanation thereof is omitted here.

As explained above, in the third embodiment, the sewing machine **1** can identify the transmission timing of the ultrasonic wave by detecting the electromagnetic wave signal output by the ultrasonic pen **92**. In other words, there is no need to provide a cable to connect the ultrasonic pen **92** and the sewing machine **1**. As a result, there is no way the cable can be an obstruction to the operation. Thus, the user can easily specify the specified position on the work cloth **100** using the ultrasonic pen **92**.

In the third embodiment, the ultrasonic pen **92** may be provided with a known timer circuit and the timer circuit may be connected to the electromagnetic wave output circuit **921**. In this case, the electromagnetic wave output circuit **921** of the ultrasonic pen **92** may output an electromagnetic wave signal that notifies the CPU **61** of the time at which the switch **913** is turned on. The CPU **61** may receive the electromagnetic wave signal via the electromagnetic wave detector **97** and may identify the time notified by the electromagnetic wave signal. The CPU **61** may acquire the identified time as the transmission timing of the ultrasonic wave.

The electromagnetic wave signal output from the electromagnetic wave output circuit **921** may be an electromagnetic wave signal of an arbitrary frequency. For example, the electromagnetic wave signal may be a microwave or infrared light.

Fourth Embodiment

A fourth embodiment will be explained. As shown in FIG. **13**, the fourth embodiment is different from the third embodiment in that the sewing machine **1** is provided with a receiver **96** in addition to the receivers **94** and **95** and in that the ultrasonic pen **92** is not provided with the electromagnetic wave output circuit **921**, as will be described below in detail. The receiver **96** is provided on the left surface **17** of the pillar **12**. The receiver **96** has the same configuration as the receivers **94** and **95**. The receiver **96** is provided such that an opening (not shown in the drawings) of the receiver **96** is directed to the left. The CPU **61** may detect the ultrasonic wave using the receivers **94**, **95** and **96** and may calculate the specified coordinates E based on the detection timings T**2** of the receivers **94**, **95** and **96**. Unlike the first embodiment to the third embodiment, the CPU **61** does not acquire the transmission timing T**1** of the ultrasonic wave, and does not use the transmission timing T**1** when calculating the specified coordinates E. An electrical configuration of the sewing machine **1** according to the fourth embodiment is a configuration obtained by removing the electromagnetic wave detector **97** and the electromagnetic wave output circuit **921** from the block diagram shown in FIG. **12** that shows the electrical configuration of the sewing machine **1** according to the third embodiment.

A method for identifying a position on the work cloth **100** specified by the ultrasonic pen **92** will be explained with reference to FIG. **14**. The may user specify the specified position on the work cloth **100** by causing the pen tip **911** of the ultrasonic pen **92** to touch the work cloth **100**. The left-right direction and the up-down direction of FIG. **14** respectively correspond to the X direction and the Y direction. A direction from the near side to the far side of FIG. **14** corresponds to the Z direction. Coordinates D of the receiver **96** are denoted by (Xd, Yd, Zd). A distance between the specified coordinates E and the coordinates D of the receiver **96** is referred to as a "distance ED".

The distance ED can be expressed by the coordinates B, C, D, and E based on the Pythagorean theorem. The distance ED and the coordinates D and E satisfy a relationship of the following Formula (7).

$$(Xd-Xe)^2+(Yd-Ye)^2+(Zd-Ze)^2=(ED)^2 \quad \text{Formula (7)}$$

In the same manner as Formulas (1) and (2) described above, Formula (7) is the same as the equation of a spherical surface (whose radius is the distance ED), the origin of which is the coordinates D and on which the specified coordinates E is.

A time required from when the ultrasonic wave is transmitted from the ultrasonic pen **92** at the specified coordinates E to when the ultrasonic wave reaches the receiver **96** is referred to as a propagation time Td. In this case, the distance ED can be expressed by the following Formula (8).

$$ED=V\times Td \quad \text{Formula (8)}$$

Further, Formulas (4) and (8) can be transformed into the following Formulas (9) and (10).

$$EC=V\times Tc=V\times(Tc-Tb)+V\times Tb \quad \text{Formula (9)}$$

$$ED=V\times Td=V\times(Td-Tb)+V\times Tb \quad \text{Formula (10)}$$

A propagation time difference (Tc−Tb) in Formula (9) is the same as the difference between the detection timing T**2** at which the ultrasonic wave is detected via the receiver **95** and the detection timing T**2** at which the ultrasonic wave is detected via the receiver **94**. In a similar manner, a propagation time difference (Td−Td) in Formula (10) is the same as the difference between the detection timing T**2** at which the ultrasonic wave is detected via the receiver **96** and the detection timing T**2** at which the ultrasonic wave is detected via the receiver **94**. Accordingly, Formulas (9) and (10) can be transformed into the following Formulas (11) and (12). Detection timings at which the ultrasonic wave is detected via the receivers **94**, **95**, and **96** irrespectively referred to as T**2***b*, T**2***c* and T**2***d*.

$$EC=V\times(T2c-T2b)+V\times Tb \quad \text{Formula (11)}$$

$$ED=V\times(T2d-T2b)+V\times Tb \quad \text{Formula (12)}$$

Following Formulas (13), (14), and (15) can be obtained by substituting Formulas (3), (11), and (12) into Formulas (1), (2), and (7).

$$(Xb-Xe)^2+(Yb-Ye)^2+(Zb-Ze)^2=(V\times Tb)^2 \quad \text{Formula (13)}$$

$$(Xc-Xe)^2+(Ye-Ye)^2+(Zc-Ze)^2=\{V\times(T2c-T2b)+V\times Tb\}^2 \quad \text{Formula (14)}$$

$$(Xd-Xe)^2+(Yd-Ye)^2+(Zd-Ze)^2=\{V\times(T2d-T2b)+V\times Tb\}^2 \quad \text{Formula (15)}$$

In Formulas (13), (14), and (15), the coordinates B (Xb, Yb, Zb), the coordinates C (Xc, Ye, Zc), the coordinates D (Xd, Yd, Zd), and the sonic velocity V are known values and are stored in advance in the ROM **62**. The detection timings T**2***b*, T**2***c* and T**2***d* respectively correspond to times at which The CPU **61** detects the ultrasonic wave via the receivers **94**, **95**, and **96** (step S**43**, refer to FIG. **15**). The value Ze of the specified coordinates E (Xe, Ye, Ze) is deemed to be zero. Based on the above, the values Xe, Ye, and Tb can be calculated by solving the simultaneous equations represented by Formulas (13), (14), and (15). In this manner, the specified coordinates E (Xe, Ye, Ze (=0)) on the work cloth **100** that are specified using the ultrasonic pen **92** are calculated.

Processing that is performed by the CPU **61** of the sewing machine **1** to identify the specified position will be explained with reference to FIG. **15**. The main processing is performed by the CPU **61** in accordance with the program stored in the ROM **62**. The CPU**61** may start the main processing when, for example, a command to perform sewing is input by a panel operation.

The CPU **61** determines whether at least one of the receivers **94**, **95**, and **96** has detected the ultrasonic wave transmitted from the ultrasonic pen **92** (step S**41**). If none of the receivers **94**, **95**, and **96** has detected the ultrasonic wave (NO at step S**41**), the CPU **61** determines whether the ultrasonic wave has been detected by at least one of the receivers **94**, **95**, and **96** after the main processing has been started (step S**61**). If none of the receivers **94**, **95** and **96** has detected the ultrasonic wave after the main processing has been started (NO at step S**61**), the processing returns to step S**41**. If the ultrasonic wave has been detected by at least one of the receivers **94**, **95**, and **96** after the main processing has been started (YES at step S**61**), the CPU **61** determines whether a predetermined time period (for example, one second) has elapsed from when the ultrasonic wave has been detected for the first time after the start of the main processing (step S**63**). If the predetermined time period has not elapsed (NO at step S**63**), the processing returns to step S**41**. If the predetermined time period has elapsed (YES at step S**63**), the CPU **61** displays an error message, on the LCD **15**, indicating that the ultrasonic wave has not been detected (step S**65**). The processing returns to step S**41**.

If at least one of the receivers **94**, **95**, and **96** has detected the ultrasonic wave within the predetermined time period (YES at step S**41**), the CPU **61** identifies a time at which the ultrasonic wave has been detected. The CPU **61** acquires the identified time as the detection timing T**2** (step S**43**). The CPU **61** stores the acquired detection timing T**2** in the RAM **63**.

The CPU **61** determines whether all the receivers **94**, **95**, and **96** have detected the ultrasonic wave (step S**45**). If at least one of the receivers **94**, **95**, and **96** has not detected the ultrasonic wave (NO at step S**45**), the processing returns to step S**41**. If all the receivers **94**, **95**, and **96** have detected the ultrasonic wave (YES at step S**45**), the CPU **61** calculates differences "T**2***c*-T**2***b*" and "T**2***d*-T**2***b*" between the detection timings (step S**47**). The CPU **61** calculates the distances EB, EC, and ED based on the calculated differences and the propagation time Tb (step S**49**) (refer to Formulas (3), (11), and (12)). The CPU **61** substitutes the coordinates B (Xb, Yb, Zb), the coordinates C (Xc, Ye, Zc), the coordinates D (Xd, Yd, Zd), and the distances EB, EC, and ED into Formulas (13), (14), and (15), and solves the simultaneous equations. Thus, the CPU **61** calculates the specified coordinates E (Xe, Ye, Ze (=0)). In this manner, the CPU **61** identifies the position specified using the ultrasonic pen **92**, namely, the specified position (step S**51**). Processing from steps S**27** to S**33** is performed in the same manner as in the first embodiment to the third embodiment (refer to FIG. **7**) and an explanation thereof is thus omitted here.

As explained above, in the fourth embodiment, the sewing machine **1** can calculate the specified coordinates E using only the detection timings T**2** without using the transmission timing T**1**, unlike the first embodiment to the third embodiment. Therefore, there is no need to provide structural elements that are necessary to identify the transmission timing T**1**, such as the signal output circuit **914** (refer to FIG. **5**) in the first embodiment, or the electromagnetic wave detector **97** and the electromagnetic wave output circuit **921** in the third embodiment. As a result, in the fourth embodiment, the specified coordinates E can be calculated with a simpler configuration than the configurations of the first embodiment to the third embodiment.

In the fourth embodiment, the three positions in which the receivers **94**, **95**, and **96** are provided are not limited to the lower left end and the lower right end of the head **14** of the sewing machine **1** and the left surface **17** of the pillar **12**. For example, all the receivers **94**, **95**, and **96** may be provided on the head **14**. For example, the receiver **94** may be provided on the rear side of the lower left end of the head **14**, the receiver **95** may be provided on the rear side of the lower right end of the head **14**, and the receiver **96** may be provided at substantially the center of the front side of the lower end of the head **14**.

The receivers **94** and **95** may be provided on the left and right sides of the presser bar **31** or the presser foot **30**, and the receiver **96** may be provided on the left surface **17** of the pillar **12**. The receiver **96** may be provided on the lower surface of the arm **13**.

The receivers **94** and **95** may be provided on the left and right sides of the presser bar **31** or the presser foot **30**, and the receiver **96** may be provided at substantially the center, in the left-right direction, of the front side of the lower end of the head **14**.

As explained above, the receivers **94**, **95**, and **96** may be provided on any of the head **14**, the presser foot **30**, the presser bar **31**, the left surface **17** of the pillar **12** and the lower surface of the arm **13**. The combinations of the portions of the receivers **94**, **95**, and **96** are not limited to those of the above-described fourth embodiment and the modified examples.

In a case where the embroidery unit **2** is attached to the sewing machine **1** and used, the receivers **94**, **95**, and **96** may be provided on the carriage **52** (refer to FIG. **8** to FIG. **10**). In this case, the receivers **94** and **95** may be respectively provided at the front end and the rear end of the top surface of the carriage **52**, and the receiver **96** may be provided at substantially the center, in the front-rear direction, of the top surface of the carriage **52**. The receivers **94** and **95** may be respectively provided at the front end and the rear end of the top surface of the carriage **52**, and the receiver **96** may be provided on the rear side of the lower right end of the head **14**. The receivers **94** and **95** may be respectively provided at the front end and the rear end of the top surface of the carriage **52**, and the receiver **96** may be provided on the left surface **17** of the pillar **12**.

Fifth Embodiment

A fifth embodiment will be explained. As shown in FIG. **16**, a multi-needle sewing machine **3** (hereinafter referred to as a sewing machine **3**) according to the fifth embodiment includes a plurality of needle bars. The sewing machine **3** is provided with receivers **131** and **132**. A configuration of the sewing machine **3** will be explained with reference to FIG. **16** to FIG. **18**. In the explanation below, it is defined that the upper side, the lower side, the left side, the right side, the near side, and the far side of FIG. **16** are respectively defined as the upper side, the lower side, the left side, the right side, the front side, and the rear side of the sewing machine **3**. That is, the direction in which a pillar **103**, which will be described below, extends is the up-down direction of the sewing machine **3**. The direction in which an arm **104** extends is the front-rear direction of the sewing machine **3**.

As shown in FIG. **16** and FIG. **17**, a main body **120** of the sewing machine **3** includes a support portion **102**, the pillar **103**, and the arm **104**. The support portion **102** is formed in an inverted U shape in a plan view and supports the whole of the sewing machine **3**. A left and right pair of guide grooves **125** are provided on a top surface of the support portion **102**. The guide grooves **125** extend in the front-rear direction. The pillar **103** extends upward from the rear end of the support portion **102**. The arm **104** extends forward from the upper end of the pillar **103**. A needle bar case **121** is mounted on the leading end (the front end) of the arm **104** such that the needle bar case **121** can be moved in the left-right direction. Ten needle bars (not shown in the drawings) that extend in the up-down direction are provided inside the needle bar case **121** such that the needle bars are arranged at equal intervals in the left-right direction. One of the ten needle bars that is in a sewing position may be slidingly moved in the up-down direction by a needle bar drive mechanism (not shown in the drawings) that is provided inside the needle bar case **121**. A sewing needle **135** can be attached to and detached from the lower end of each of the needle bars.

An operation portion **106** is provided on the right side of a central portion, in the front-rear direction, of the arm **104**. The operation portion **106** includes a liquid crystal display (LCD) **107**, a touch panel **108**, and an operation switch **141**. The LCD **107** may display various types of information, such as an operation image that is used for the user to input a command, for example. The touch panel **108** is used to accept a command from the user. The user may perform an operation of pressing the touch panel **108** using a finger or a dedicated touch pen. Hereinafter, this operation is referred to as a "panel operation". The touch panel **108** detects a position pressed by the finger, the dedicated touch pen, or the like, and the sewing machine **3** determines the item that corresponds to the detected position. In this manner, the sewing machine **3** recognizes the selected item. By the panel operation, the user can select or set a pattern to be sewn and various types of conditions, such as sewing conditions. The operation switch **141** is used to command the start or stop of the sewing.

A cylinder bed **110** is provided below the arm **104**. The cylinder bed **110** extends forward from the lower end of the pillar **103**. A shuttle (not shown in the drawings) is provided inside the leading end (the front end) of the cylinder bed **110**. The shuttle may house a bobbin (not shown in the drawings) around which a lower thread (not shown in the drawings) is wound. A shuttle mechanism (not shown in the drawings) is provided inside the cylinder bed **110**. The shuttle mechanism (not shown in the drawings) may drive the shuttle. A needle plate **116**, which has a rectangular shape in a plan view, is provided on a top surface of the cylinder bed **110**. A needle hole (not shown in the drawings), through which the sewing needle **135** may pass, is formed in the needle plate **116**.

A left and right pair of thread spool stands **112** are provided at the rear side of a top surface of the arm **104**. Ten thread spools (not shown in the drawings), the number of which is the same as the number of the needle bars, can be placed on the pair of thread spool stands **112**. A upper thread (not shown in the drawings) may be supplied from a thread spool placed on one of the thread spool stands **112**. The upper thread may be supplied to an eye (not shown in the drawings) of the sewing needle **135** that is attached to the lower end of each of the needle bars, via a thread guide **117**, a tensioner **118**, a thread take-up lever **119**, and the like. The ultrasonic pen **91** may be connected to the sewing machine **3** via the cable **912**, in the same manner as in the first embodiment.

An embroidery frame movement mechanism **111** (refer to FIG. **18**) is provided below the arm **104**. The embroidery frame movement mechanism **111** may detachably support an embroidery frame **184** (refer to FIG. **18**). Various types of embroidery frames can be used as the embroidery frame **184**. The embroidery frame **184** may hold the work cloth **100**. The embroidery frame movement mechanism **111** may be driven by an X axis motor (not shown in the drawings) and a Y axis

motor (not shown in the drawings), and may move the embroidery frame **184** in the front-rear direction and in the left-right direction.

The embroidery frame movement mechanism **111** will be explained with reference to FIG. **18**. The embroidery frame movement mechanism **111** includes a holder **124**, an X carriage **122**, an X axis drive mechanism (not shown in the drawings), a Y carriage **123**, and a Y axis movement mechanism (not shown in the drawings). The holder **124** may detachably support the embroidery frame **184**. The X carriage **122** is a plate member that is long in the left-right direction. A part of the X carriage **122** protrudes forward from the front face of the Y carriage **123**. The holder **124** is attached to the X carriage **122**. The X carriage **122** may move in the left-right direction (the X axis direction) using the X axis motor as a driving source.

The Y carriage **123** has a box shape that is long in the left-right direction. The Y carriage **123** supports the X carriage **122** such that the X carriage **122** can be moved in the left-right direction. The Y axis movement mechanism (not shown in the drawings) is provided with a left and right pair of moving members (not shown in the drawings). The moving members are coupled to lower portions of the left and right ends of the Y carriage **123**. The moving members pass through the guide grooves **125** (refer to FIG. **16**) in the up-down direction. The moving members may be moved in the front-rear direction (the Y axis direction) along the guide grooves **125**, using the Y axis motor as a driving source. The Y carriage **123** coupled to the moving members and the X carriage **122** supported by the Y carriage **123** may be moved in the front-rear direction (the Y axis direction) along with the movement of the moving members. In a state in which the embroidery frame **184** that holds the work cloth **100** is attached to the holder **124**, the work cloth **100** is arranged between one of the needle bars and the needle plate **116**.

As shown in FIG. **16** to FIG. **18**, the receiver **131** is provided at the left end of a top surface of the Y carriage **123**, and the receiver **132** is provided at the right end of the top surface of the Y carriage **123**. The receivers **131** and **132** are configured to receive an ultrasonic wave. The receivers **131** and **132** have the same configuration as the receiver **94**. The embroidery frame **184** attached to the folder **124** is located at the front of the Y carriage **123**. Therefore, the receivers **131** and **132** are located above the work cloth **100** held by the embroidery frame **184**. Openings provided in the receivers **131** and **132** are directed forward.

Processing that is performed by a CPU (not shown in the drawings) of the sewing machine **3** to identify the specified position will be briefly explained with reference to FIG. **7**. In a case where the CPU detects an electrical signal output from the signal output circuit **914** of the ultrasonic pen **91** via the cable **912** (YES at step S**11**), the CPU acquires the transmission timing T**1** (step S**13**). In a case where the CPU detects the ultrasonic wave transmitted from the ultrasonic pen **91** via the receivers **131** and **132** (YES at step S**15**), the CPU identifies a time at which the ultrasonic wave is detected by the receiver **131** and a time at which the ultrasonic wave is detected by the receiver **132**, and acquires the identified times as the detection timings T**2** (step S**17**). The CPU calculates the specified coordinates E and identifies the specified position (steps S**21** to S**25**), In a case where a panel operation is performed to start sewing (YES at step S**29**), the CPU controls the X axis motor and the Y axis motor and thereby moves the embroidery frame **184** such that the position of the specified coordinates E on the work cloth **100** matches a needle drop point (step S**31**). The CPU starts sewing on the work cloth **100**. The CPU drives the needle bar and the shuttle mechanism simultaneously with the embroidery frame being moved in the left-right direction (the X direction) and the front-rear direction (the Y direction). The sewing needle attached to the needle bar sews an embroidery pattern on the work cloth **100** held by the embroidery frame. In this manner, the embroidery pattern is sewn in the specified position on the work cloth **100** (step S**33**).

The receivers **131** and **132** are provided on the Y carriage **123**. Therefore, the ultrasonic wave that is transmitted from the ultrasonic pen **91** when the pen tip **911** is in contact with the work cloth **100** is unlikely to be shielded by a hand or an arm of the user who uses the ultrasonic pen **91** (refer to condition (A)). The distance between the receivers **131** and **132** is separated by a length, in the left-right direction, of the Y carriage **123**. Therefore, the receivers **131** and **132** are sufficiently separated from each other (refer to condition (B)). The distances, in the X direction and the Y direction, from the needle hole (the origin) of the needle plate **116** to the receivers **131** and **132** are large (refer to condition (C)). The distances between the origin and the receivers **131** and **132** are not extremely large (refer to condition (D)). The receivers **131** and **132** are provided above the cylinder bed **110** (refer to condition (E)).

As described above, in the fifth embodiment, the sewing machine **3** is provided with the receivers **131** and **132**. The sewing machine **3** can identify the specified position by detecting the ultrasonic wave by each of the receivers **131** and **132**. The positions in which the receivers **131** and **132** are provided satisfy all the above-described conditions (A) to (E). Therefore, the sewing machine **3** can calculate the specified coordinates E more precisely and can perform sewing on the work cloth **100**. Further, the height from the cylinder bed **110** to the receivers **131** and **132** is sufficiently small. As a result, the influence caused by approximating the value Ze in Formulas (5) and (6) to zero may decrease. Therefore, the error of the calculated specified coordinates E may become small.

In the above-described fifth embodiment, the sewing machine **3** may be provided with the ultrasonic pen **92** that may output an electromagnetic wave signal, instead of the ultrasonic pen **91**. The receivers **131** and **132** may be provided in positions other than the Y carriage **123**. For example, the receivers **131** and **132** may be provided on a front surface of the pillar **103** and a lower surface of the arm **104**.

The sewing machine **3** may be provided with three receivers as in the fourth embodiment. The sewing machine **3** may identify the specified position based only on the detection timings. In this case, the receivers may be provided on any positions on the sewing machine **3**, without being limited to the Y carriage **123**. For example, the receivers may be provided on the front surface of the pillar **103** and the lower surface of the arm **104**.

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The number of the receivers may be one. For example, it is assumed that the one receiver is the receiver **94** that is provided on the left lower end of the head **14**. Then, with respect to the coordinates B indicating the position of the receiver **94**, specified coordinates indicating the specified position specified by the ultrasonic pen **91** are referred to as coordinates F. At this time, the X coordinates of the coordinates B and the coordinates F are assumed to be the same. To simplify an explanation, Z coordinates are omitted in the following explanation. In other words, the coordinates B are assumed to be (Xb, Yb) and the coordinates F are assumed to be (Xb, Yf). In this case, it is possible to calculate a distance FB between the coordinates F and the coordinates B in the Y direction, based on the propagation time required for the ultrasonic wave

transmitted from the ultrasonic pen **91** that is at the coordinates F of the specified position to reach the receiver **94**. The coordinates B are known values. Thus, with respect to the needle drop point that is the origin, the Y coordinate "Yf" of the coordinates F of the specified position can be calculated.

The apparatus and methods described above with reference to the various embodiments are merely examples. It goes without saying that they are not confined to the depicted embodiments. While various features have been described in conjunction with the examples outlined above, various alternatives, modifications, variations, and/or improvements of those features and/or examples may be possible. Accordingly, the examples, as set forth above, are intended to be illustrative. Various changes may be made without departing from the broad spirit and scope of the underlying principles.

What is claimed is:

1. A sewing machine comprising:
a bed;
a pillar that extends upward from the bed;
an arm that faces the bed and that extends from the pillar;
a head that is provided at a leading end of the arm;
a plurality of detecting portions that are provided in different positions on the sewing machine, the plurality of detecting portions being provided above a top surface of the bed, the plurality of detecting portions being provided on at least one of a first section of the head, a second section of the head, a presser bar, and a presser foot, the first section being a section, on an extending side of the arm, of the pillar, the second section being a lower section of the head, the presser bar being provided in a lower portion of the head, the presser foot being attachable to the presser bar, and each of the plurality of detecting portions being configured to detect an ultrasonic wave that has been transmitted from a transmission source;
a processor; and
a memory that is configured to store computer-readable instructions that instruct the sewing machine to execute steps comprising:
identifying a position of the transmission source of the ultrasonic wave based on information pertaining to the ultrasonic wave that has been detected by each of the plurality of detecting portions; and
controlling sewing based on the position of the transmission source that has been identified.

2. A sewing machine comprising:
a moving portion to which an embroidery frame can be attached and that is configured to move the embroidery frame, the embroidery frame being configured to hold a work cloth;
a plurality of detecting portions that are provided in different positions on the sewing machine, the plurality of detecting portions being provided at positions of the moving portion that are above a position to which the embroidery frame can be attached, and each of the plurality detecting portions being configured to detect an ultrasonic wave that has been transmitted from a transmission source;
a processor; and
a memory that is configured to store computer-readable instructions that instruct the sewing machine to execute steps comprising:
identifying a position of the transmission source of the ultrasonic wave based on information pertaining to the ultrasonic wave that has been detected by each of the plurality of detecting portions; and
controlling sewing based on the position of the transmission source that has been identified.

3. The sewing machine according to claim **1**, wherein
the computer-readable instructions further instruct the sewing machine to execute a step comprising acquiring a transmission timing of the ultrasonic wave, and
the identifying the position of the transmission source of the ultrasonic wave includes identifying the position of the transmission source of the ultrasonic wave by calculating a distance between the transmission source and each of the plurality of detecting portions, based on the transmission timing that has been acquired and on a detecting timing at which the ultrasonic wave was detected by each of the plurality of detecting portions.

4. The sewing machine according to claim **3**, further comprising:
a receiving portion configured to receive an electromagnetic wave signal that indicates the transmission timing of the ultrasonic wave, wherein
the acquiring the transmission timing of the ultrasonic wave includes acquiring, as the transmission timing, the transmission timing indicated by the electromagnetic wave signal that has been received by the receiving portion.

5. The sewing machine according to claim **1**, wherein
the plurality of detecting portions are at least three detecting portions provided in different positions, and
the identifying the position of the transmission source of the ultrasonic wave includes identifying the position of the transmission source of the ultrasonic wave by calculating a distance between the transmission source and each of the at least three detecting portions, based on a detection timing at which the ultrasonic wave was detected by each of the at least three detecting portions.

6. The sewing machine according to claim **1**, further comprising:
a transmitting portion configured to transmit the ultrasonic wave, wherein
each of the plurality of detecting portions is configured to detect the ultrasonic wave that has been transmitted from the transmitting portion, and
the identifying the position of the transmission source of the ultrasonic wave includes identifying a position of the transmission portion based on the information pertaining to the ultrasonic wave that has been detected by each of the plurality of detecting portions.

7. A sewing machine comprising:
a bed,
a plurality of detecting portions that are provided in different positions on the sewing machine, the plurality of detecting portions being provided above a top surface of the bed, the plurality of detecting portions being provided at positions in an opposite side of a side in which the bed is positioned in relation to a work cloth that is configured to be placed on the bed, and each of the plurality of detecting portions being configured to detect an ultrasonic wave that has been transmitted from a transmission source;
a processor; and
a memory that is configured to store computer-readable instructions that instruct the sewing machine to execute steps comprising:
identifying a position of the transmission source of the ultrasonic wave based on information pertaining to the ultrasonic wave that has been detected by each of the plurality detecting portions; and

controlling sewing based on the position of the transmission source that has been identified.

8. The sewing machine according to claim **2**, wherein

the plurality of detecting portions are provided at positions, of the moving portion, above the work cloth held by the embroidery frame.

9. An embroidery unit that can be attached to and detached from a bed of a sewing machine, and to which an embroidery frame can be attached, and that is configured to move the embroidery frame, the embroidery frame being configured to hold a work cloth, the embroidery unit comprising:

a moving portion to which the embroidery frame can be attached and that is configured to move the embroidery frame;

a plurality of detecting portions that are provided in different positions on the embroidery unit, the plurality of detecting portions being provided at positions of the moving portion that are above a position to which the embroidery frame can be attached, and each of the plurality of detecting portions being configured to detect an ultrasonic wave that has been transmitted from a transmission source; and

a notifying portion configured to notify the sewing machine of a detection timing at which the ultrasonic wave was detected by each of the plurality of detecting portions, wherein

the embroidery unit is configured to move the work cloth based on a position of the transmission source of the ultrasonic wave that has been identified by the sewing machine based on the detection timing that has been notified by the notifying portion.

10. The embroidery unit according to claim **9**, wherein

the plurality of detecting portions are provided at positions, of the moving portion, above the work cloth held by the embroidery frame.

11. The sewing machine according to claim **2**, wherein

the computer-readable instructions further instruct the sewing machine to execute a step comprising acquiring a transmission timing of the ultrasonic wave, and

the identifying the position of the transmission source of the ultrasonic wave includes identifying the position of the transmission source of the ultrasonic wave by calculating a distance between the transmission source and each of the plurality of detecting portions, based on the transmission timing that has been acquired and on a detecting timing at which the ultrasonic wave was detected by each of the plurality of detecting portions.

12. The sewing machine according to claim **11**, further comprising:

a receiving portion configured to receive an electromagnetic wave signal that indicates the transmission timing of the ultrasonic wave, wherein

the acquiring the transmission timing of the ultrasonic wave includes acquiring, as the transmission timing, the transmission timing indicated by the electromagnetic wave signal that has been received by the receiving portion.

13. The sewing machine according to claim **2**, wherein

the plurality of detecting portions are at least three detecting portions provided in different positions, and

the identifying the position of the transmission source of the ultrasonic wave includes identifying the position of the transmission source of the ultrasonic wave by calculating a distance between the transmission source and each of the at least three detecting portions, based on a detection timing at which the ultrasonic wave was detected by each of the at least three detecting portions.

14. The sewing machine according to claim **2**, further comprising:

a transmitting portion that is configured to transmit the ultrasonic wave, wherein

each of the plurality of detecting portions is configured to detect the ultrasonic wave that has been transmitted from the transmitting portion, and

the identifying the position of the transmission source of the ultrasonic wave includes identifying a position of the transmission portion based on the information pertaining to the ultrasonic wave that has been detected by the at least one detecting portion.

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